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ROSE AND CARLESS'S
MANUAL OF SURGERY

For Students and Practitioners

NINTH EDITION
(REPRINTED)

REVISED BY

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TO THE LATE

LORD LISTER, LL.D., F.R.S., O.M.,

Late President of the Royal Society,

THE FATHER OF ANTISEPTIC SURGERY,

THIS WORK WAS, WITH PERMISSION,

Dedicated by the Authors,

IN GRATEFUL ACKNOWLEDGMENT OF THE MANY ADVANTAGES

THEY DERIVED

WHILST ASSOCIATED WITH HIM IN HIS WORK

AT KING'S COLLEGE HOSPITAL.

PREFACE TO THE NINTH EDITION

THE triennium which has elasped since the issue of the eighth edition of this Manual has been characterized, not by the discovery of any revolutionary or wonder-working novelty, but by the steady elaboration of ideas and methods which had already been introduced, and required time for their investigation. Salvarsan and radium in particular may be mentioned as subjects to the consideration of which a vast amount of work has been devoted. Salvarsan stands as the conqueror of the worst ill-effects of syphilis, if only it be employed in time; radium has proved itself a potent agent for good in many cases, but the magniloquent prophets who hailed it as the victor of cancer have not yet proved their claims. Steady progress is being made in all the varied realms of research which are touched on in this work, and an effort has been made to incorporate therein the most important, keeping in view the double purpose of this manual—viz., to instruct students and to help practitioners. Room has been found for a new chapter on modern methods of treatment by heat, light, electricity, etc., and for other fresh subjects. Many new illustrations have been added, as well as a few more coloured plates, and this without adding a single page to the book. The paper on which it is printed is slightly thinner than previously, so as to keep its weight within the requirements of the postal authorities, who distribute it far and wide overseas. I trust that this edition may prove even more helpful than those which have preceded it, and pray that when the tenth edition is required the sounds of war and strife, which boom on the ear as these lines are penned, may long have ceased, and that a righteous peace leading to a happy competition of race with race in the effort to promote, not the destruction, but the welfare of mankind of all nationalities, may have been established.

I have to thank many who have kindly helped me in preparing this edition. Dr. Emery has again answered pathological queries; Dr. Knox has helped me with radiographic preparations; Dr. Silk has kindly revised the chapter on Anæsthetics. Mr. John Everidge, Dr. Thurston Holland, Dr. Knevitt, Dr. Salmond, Dr. Mack, and others have helped with photographs, which have been prepared for press by the artistic skill of Dr. Dupuy. To one and all I offer my hearty thanks, as also to Mr. Eric Gauntlett, who helped me until called out on active service. Again I have to acknowledge the kindly courtesy of my publishers, who have cheerfully assisted me in every way possible.

ALBERT CARLESS.

6. UPPER WIMPOLE STREET, W.,
September, 1914.

PREFACE TO THE FIRST EDITION

In preparing this Manual of Surgery for the profession, we have endeavoured to meet what we think is at the present time a genuine need. The many large and valuable text-books and works of reference already in existence are almost more than the ordinary student can master during the time at his disposal. It has therefore been our aim to present the facts of surgical science in a concise and succinct form, so as to satisfy the needs of the student, even of those who are preparing for the higher examinations. At the same time, the requirements of the general practitioner have not been overlooked, for we have taken care to discuss in detail those conditions which are most likely to be met with in ordinary practice. The main difficulty has been to compress into a small space the ever-increasing amount of material available, so that we have only been able to sketch in outline much that could have been elaborately described did the size of the book permit. For the same reason, historical and bibliographical references have to a large extent been omitted, whilst diseases of special regions—such as the eye, ear, and female genital organs—are also practically excluded, except in so far as they encroach on the domains of general surgery. The progress of bacteriology and the influence of antisepsis have so transformed the characters and extended the scope of surgical work, that many of the traditions and theories of the past have had to be discarded, although at the same time we have endeavoured to preserve and respect that which has been shown to be good and useful in the laborious researches and accumulated experiences of bygone generations.

In conclusion, our best thanks are due to Dr. St. Clair Thomson, who has kindly looked through the proofs of the sections devoted to the Nose and Ear; to Dr. Silk, who has fulfilled a similar office in reference to the chapter on Anæsthetics; to Mr. William Turner for preparing the Index; and to Dr. Arthur Griffiths, late of the Bristol General Hospital, who has drawn several of the pictures, and given other valuable assistance.

Many of the illustrations have been specially prepared for this work, but we have also to acknowledge the loan of blocks from Messrs. Veit and Co., of Leipzig; from Messrs. Cassell and Co., J. and A. Churchill, Longmans and Co.; and from the editors of the *Lancet* for the loan of Fig. 287. The various sources from which these are derived are acknowledged throughout the book. Illustrations of instruments are mainly derived from Messrs. Down Brothers, who have kindly placed them at our disposal.

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LONDON,
May 1, 1898.

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PLATE I.

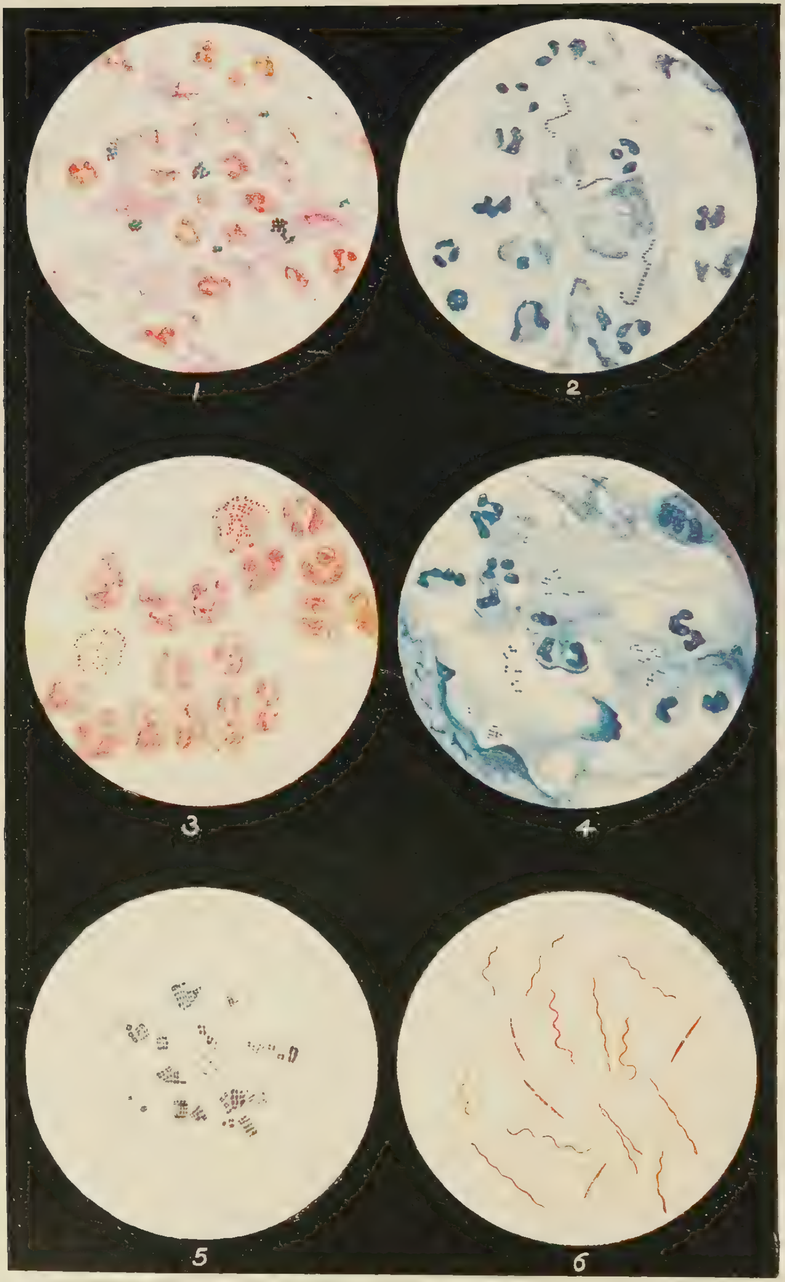

Fig. 1.—Staphylococci in pus. Staining—Gram and dilute carbol-fuchsin. *Fig.* 2.—Streptococci in pus. Staining—methylene blue. *Fig.* 3.—Gonococci in pus. Gram and carbol-fuchsin, only the latter of which has stained. *Fig.* 4.—Pneumococci in sputum. Methylene blue. *Fig.* 5.—Sarcinae, from a culture. Gram's stain. *Fig.* 6.—Spirilla (with a few bacilli) from Vincent's angina. Carbol-fuchsin.

[*To face page 1.*

A MANUAL OF SURGERY

CHAPTER I.

BACTERIOLOGY—INFECTION—IMMUNITY.

THE importance to the surgeon of a study of bacteriology is twofold. In the first place, many surgical diseases (especially those of an inflammatory nature) are due to the action of bacteria; secondly, these organisms are practically ubiquitous, and in the absence of suitable precautions will infallibly enter any external wound, whether accidental or intentional, and by their development and the inflammatory troubles which result therefrom delay the process of healing, or even give rise to fatal results. Hence every surgeon must have a general knowledge of the habits and distribution of the more important species of bacteria, their mode of life, and the mechanism by which they give rise to morbid processes in the human body, as well as of the methods used in their investigation. It was only by means of such knowledge that the present methods of treating wounds were evolved, and without it these methods cannot be intelligently applied in actual practice. Moreover, the diagnosis of disease is often much assisted by the bacteriological examination of morbid products, and information of the highest importance may be obtained thereby.

Bacteria (schizomycetes, or fission fungi) form a very important group of the lower plants. Although several thousand species have been described, comparatively few are of importance in medicine or surgery. They may be defined as minute unicellular plants, which reproduce themselves by simple fission, or in some forms by endogenous spore-formation, not more than one spore being formed in each cell. They are devoid of organs except flagella, and contain no chlorophyll. Their structure is extremely simple, consisting of a delicate cell-wall (composed of cellulose or an allied substance) which encloses a mass of protoplasm, in which there may be one or more vacuoles and a few granules of unknown nature. External to the cell-wall there is sometimes a gelatinous capsule, which may serve to unite the bacterial cell loosely with its neighbours. When such capsules become very prominent, large numbers of bacteria may become embedded in a gelatinous mass, known as a *zooglœa*. Capsule-formation is of some importance in diagnosis; the pneumococcus, for example, possesses a well-marked capsule when it occurs in blood or morbid exudates, and may thereby be distinguished from many organisms otherwise resembling it.

Flagella are delicate filamentous extensions of the protoplasm, which occur in those bacteria which are possessed of spontaneous mobility. They are sometimes of great length, but are always extremely thin, and are only visible after the use of complicated staining processes. Their number is of importance in diagnosis. The typhoid bacillus, for example, has usually from twelve to twenty flagella (Plate III., Fig. 25), whilst the closely-allied *B. coli* has from three to six. It should be remembered that bacteria which are devoid of flagella often exhibit very marked Brownian movement, which the uninitiated might mistake for spontaneous motility.

Reproduction among the bacteria is extremely simple, nothing akin to sexual processes having been observed. In *simple fission* the cell becomes divided by a thin membrane into two portions, which develop into mature organisms. The two bacteria thus produced may become entirely separated from one another, or may remain more or less connected by means of the capsules described above, thereby becoming united into groups, which are more or less characteristic of the species. This process of division may take place with great rapidity, so that a suitable material which has become infected with one or two bacteria may contain vast numbers in the course of a few hours.

Spore-formation is a more complicated process, and is found only in certain of the rod-shaped bacteria or bacilli. Bacterial spores are round or oval in shape, and are formed within the bacterial cell (endospores). They consist of a thick cell-wall filled with protoplasm, which contains less water than the mature bacterium, and has, therefore, a highly refractile appearance when seen under the microscope. The shape and size of the spores have much diagnostic value; thus, the bacillus of tetanus has an almost spherical spore, which is distinctly larger than the diameter of the rod in which it is formed, whilst the spore of the anthrax bacillus is oval, and little or no broader than the rod itself. The position of the spore is also of importance. The spores of the tetanus bacillus are at the extreme end of the bacillus, giving it the appearance of a drumstick, whilst those of anthrax are central. Spores are to be regarded as resting forms adapted to maintain the life of the species under adverse conditions, and in this respect are analogous to the seeds of the higher plants. They resist drying to a far greater extent than do the bacteria themselves. Anthrax spores have been preserved in the laboratory for twenty years without loss of viability or virulence, whilst asporogenous anthrax dies in a few weeks when dried. They are also very resistant to heat. Most bacteria (when moist) are killed when exposed to a temperature of 60° C. for half an hour, whereas many spores are not killed by prolonged boiling. Lastly, they are very difficult to kill by means of antiseptics. Anthrax spores can be killed by immersion in 1 in 20 carbolic lotion, but only after several days. Of the bacilli of chief interest to the surgeon the *B. tetani*, *B. anthracis*, *B. œdematis maligni* form spores, and of these only the *B. tetani* in the body, whilst those of glanders, tubercle, diphtheria, typhoid fever, leprosy, influenza, and soft sore are asporogenous.

The **Classification** of the bacteria is based, in the first instance, on their morphology, but owing to the simplicity of the shape of the organisms, morphological characteristics have to be supplemented by physiological and cultural properties in the definition of the separate species. There are three great groups—the cocci, bacilli, and spirilla.

I. **Cocci** are organisms which are spherical, or nearly spherical. They constitute the simplest forms of bacteria, since but few species possess flagella, and spore-formation is unknown. (*a*) *Micrococci* are those forms in which there is no definite arrangement into groups. The term 'staphylococcus'—more properly the name of a species, the *Staphylococcus pyogenes*—is applied to cocci in which the individual elements are arranged in clusters resembling bunches of grapes (Plate I., Fig. 1). (*b*) *Diplococci* (Plate I., Fig. 4) are forms in which the two elements arising from the division of a single coccus remain in more or less close apposition, so that they are arranged in pairs. (*c*) *Streptococci* (Plate I., Fig. 2) are arranged in longer or shorter chains, like a necklace. This formation is due to the fact that the successive planes of division in which the cocci are divided lie parallel to one another. (*d*) In a few cases a coccus divides into two, which are again divided in a plane at right angles to the first, so that the four cocci which result lie at the corners of a square; these are called *Tetracocci*. Lastly, (*e*) *Sarcinæ* are formed by three consecutive divisions in the three planes of space, so that the eight cocci which are formed lie at the corners of a sphere (Plate I., Fig. 5), and the group resembles a bale of wool tightly tied in three directions. These cocci often divide again, and lead to the formation of composite masses.

II. **Bacilli** (Plate III., p. 128) are bacteria which have the form of straight or curved rods, the long diameter of the cell being greatly larger than the short diameter. Spore-formation is common in this group, and many of its members possess flagella, and are therefore motile. The group is not subdivided, but the terms *streptobacillus* for those which remain adherent in chains, and *leptothrix* for forms which produce long threads before breaking up into short rods, are convenient.

III. **Spirilla** are rods which are uniformly curved in the three planes of space, so that when sufficiently long they form corkscrew-like spirals. Short forms also occur, and these are sometimes designated *vibrios*, the term 'spirilla' being then reserved for the long spiral forms. The spirilla are not of much surgical importance, the only well-known pathogenic varieties being the *V. choleræ*

Asiaticæ and the spirillum of relapsing fever (Plate I., Fig. 6), which latter, however, is now thought to be a protozoan.

Conditions of Life.—Bacteria resemble other plants devoid of chlorophyll in being unable to form proteid from simple materials in the presence of sunlight, and have to be supplied with ready-formed organic nitrogen from animal or vegetable sources. Regarded from this standpoint, they may be divided into two classes —the *parasites*, which can obtain their pabulum only from the living animal (or plant), and the *saprophytes*, which are unable to do so, and flourish only in dead materials. The leprosy bacillus may be taken as an example of a strict parasite, since, as far as is known at present, it grows only in the living tissues, and cannot be cultivated outside the body. The term *facultative saprophyte* is applied to those organisms which prefer a parasitic existence, but which will grow under suitable conditions in dead materials. The gonococcus is a good example; it multiplies readily enough in the living mucous membrane, but grows only feebly on dead culture media. *Facultative parasites*, on the other hand, are organisms which grow best in dead materials, but which have the power of adapting themselves to a parasitic existence. It must be understood that the terms 'parasitic' and 'pathogenic' are not quite synonymous. A *pathogenic* organism is one that has the power of producing disease, and it may do so without entering the living tissues at all, as when putrefactive organisms gain access to a blood-clot in the uterus and cause toxæmia. A parasitic organism is not necessarily pathogenic, especially in the lower animals, since these frequently harbour blood-parasites without appearing to suffer therefrom in any way.

In addition to combined nitrogen, all bacteria require water, certain salts, and a suitable temperature for their growth. The necessity for water must be borne in mind in surgical practice, and every attempt must be made (by accurate co-aptation of parts, drainage, etc.) to prevent the accumulation of putrescible material in wounds or body-cavities. This is well seen in dealing with the peritoneum, the absorptive power of which is one of the chief natural defences against peritonitis. In laboratory experiments we find that large amounts of fluid cultures of pathogenic bacteria can be injected into the peritoneal cavity of animals without injury; the fluid is rapidly absorbed and bacterial growth ceases. If, however, the peritoneum is injured so that absorption is checked, the bacteria continue to grow, and fatal peritonitis results.

The requirements of different bacteria as to temperature vary greatly. The majority of those of importance in human pathology grow best at or about the body temperature (37° C.), but many forms, especially those which are commonly met with as saprophytes outside the body (such as *Staphylococcus pyogenes* and *B. coli*), grow well at 18° C., or even lower. Other forms flourish best at lower or higher temperatures than these, but they are not of pathological importance. Lower temperatures inhibit growth, but do not kill the bacteria unless applied for long periods. The destruction of bacteria and spores by heat has been already mentioned.

Light is injurious to almost all bacteria. This is especially the case with *B. tuberculosis*, which *in vitro* is killed after a very short exposure to sunlight and more slowly by diffused daylight. The action seems to depend on the formation of peroxide of hydrogen in the culture medium.

Many pathogenic organisms require free oxygen for their development, and are spoken of as *aërobes*. A few, such as the tetanus bacillus, will grow only in the complete absence of oxygen, ceasing to develop, though still remaining alive, when that gas is admitted; such organisms are called *anaërobes*. Bacteria which grow best in air, but which will also grow in its absence, are called *facultative anaërobes*, and those which grow best under anaërobic conditions, but are capable of some growth in presence of oxygen, are called *facultative aërobes*. It must be pointed out that the conditions in the living body are peculiar, in that both strict aërobes and strict anaërobes are capable of growth. Further, a strict anaërobe may grow in a fluid freely exposed to air in the presence of other organisms which have a great affinity for oxygen and rapidly absorb it. In this way tetanus bacilli may flourish in superficial wounds if other bacteria are present.

In their growth bacteria give off metabolic products which are often of great importance. The chief of these are (1) acids, such as lactic, acetic, butyric, etc.; (2) alkalies; (3) gases, such as sulphuretted hydrogen, marsh gas, etc.; (4) pigments, such as the green colouring matter produced by *B. pyocyaneus* and seen in the so-called blue pus; (5) aromatic substances, such as indol, phenol, and tyrosin; (6) alcohol and other similar bodies; (7) ferments—*e.g.*, diastase, invertase, and a ferment allied to rennin. A more important enzyme is one resembling trypsin and having the power of peptonizing proteid material. It is produced by one of the commonest pyogenic organisms (*Staphylococcus pyogenes*), and plays some part in the destruction of the tissues in suppuration. Its presence or absence is ascertained by cultivating the organism on gelatin or coagulated blood-serum, either of which is digested or 'liquefied' if the enzyme is produced. (8) Certain crystallizable organic substances of definite chemical composition, allied to the vegetable alkaloids, and spoken of as *ptomains*. They have some poisonous properties, and were once thought to be of great importance in the production of disease. (9) The true **Toxins** have never been isolated in a state of purity, but appear to be allied in chemical composition to the albumoses, and have some features in common with the enzymes. They are intensely poisonous when injected into the blood or tissues, though innocuous (in most cases) when taken by the mouth. They are very unstable substances, being readily destroyed by heat, peptic digestion, etc., and when kept in a state of solution gradually become inert.

Toxins are divided into two distinct classes: (*a*) Certain organisms, of which the most important are the bacilli of tetanus and diphtheria, produce soluble *extracellular* toxins which accumulate in the fluid in which they are grown. (*b*) In the case of many other organisms, the specific poison appears to remain locked up in the bodies of the bacteria, and is only given off under conditions which we are unable to reproduce experimentally; they are known as *intracellular* toxins. For example, the soluble products secreted by the tubercle bacillus have but little toxic action, whereas the washed bodies of the bacilli themselves are extremely poisonous.

The pathological effects of these toxins are highly diverse, but in nearly all cases they include the production of fever. Some are selective in their action, affecting only a certain class of cell—*e.g.*, the cells of the central nervous system in the case of tetanus. Others, such as those of the pyogenic bacteria, affect any tissues they may happen to reach. Under natural conditions the results vary with the amount of toxin present in the body, and with the susceptibility of the animal and of the tissues in question. Thus a very powerful toxin may immediately destroy the vitality of a part *en masse*, whilst one that is somewhat less intense in its action may kill the tissues after causing an acute inflammation. A similar but still slower process leads to caseation; in this fatty degeneration has time to supervene in the affected tissues before their death. In another group of cases the inflammation may terminate in a slower but progressive molecular death of the tissues, leading to suppuration. Finally, if a very feeble toxin acts for prolonged periods it may serve as a stimulant to growth and determine proliferation of the fibrous tissues, etc., without the development of any external signs of inflammation.

Distribution.—Bacteria are very widely distributed in nature. Their presence in *the air* varies greatly with circumstances. They are absent from the air of mountain-tops or mid-ocean, and present in vast numbers in towns. They are not given off from the surface of liquids containing them, and only remain in suspension in the air when adherent to particles of dust or moisture. They are more plentiful in dry weather than in wet, and more abundant in occupied houses than in the open air. When the atmosphere of an enclosed space is kept at rest, the dust gradually sinks to the bottom and the air becomes absolutely sterile. It has been found that the air of schoolrooms contains far fewer bacteria when the scholars are sitting quietly than when they are allowed to move about—a fact which should be borne in mind by spectators at a surgical operation. Expired air is sterile, but in speaking and coughing minute particles of fluid are ejected, and are usually charged with an abundance of bacteria, which are frequently pathogenic, and may constitute a source of danger in operations. The bacterial contents of *water* also vary greatly. That suitable for a public water-supply should contain but few bacteria, and pathogenic forms should be absent. Where this is known to be the case, the water may be used in an emergency to cleanse wounds, though even then it is desirable to sterilize it; but as a rule water from natural sources contains so many injurious bacteria that a preliminary sterilization is absolutely necessary before its use for surgical purposes. *Earth* contains vast numbers of bacteria, and pathogenic varieties are frequently present.

The human skin teems with bacteria, like anything else which is exposed to dust and dirt. The majority of these organisms are present simply by accident, and are readily removed by washing. A few, however, are normal inhabitants of the skin, and are very difficult to destroy, as they penetrate deeply. Bacteria are also present in the alimentary canal from the mouth to the anus, the external auditory meatus, the inferior meatus of the nose, the conjunctiva, the anterior portion of the male urethra, and the vulva. The superior meatus of the nose, the deeper portions of the urethra, and the upper part of the vagina in a virgin are in general sterile, as are also the healthy gall-bladder, together with the biliary and pancreatic ducts. The blood and deeper tissues of a healthy animal are usually free from germs, but careful observations have shown that the escape of small numbers of bacteria from the alimentary canal into the blood and lymph is a common, perhaps constant, occurrence. Under conditions of health these bacteria do not find suitable conditions for continued growth in the body, and are soon destroyed in the blood; but when the general vitality of the body is lowered they may persist, and, finding a suitable foothold in an area of low vitality, may develop and give rise to pathological effects. This is probably the explanation of the suppuration that sometimes occurs in deep lesions, such as the subcutaneous rupture of a muscle or ligament, and it is termed *auto-infection* (p. 72).

Methods of Observation—(1) *Microscopical Examination.*—This may be carried out on morbid material taken direct from the body, or on cultures of organisms derived therefrom. A high magnifying power ($\frac{1}{12}$-inch oil immersion) and a suitable substage condenser are necessary. The material may be stained or unstained. Unstained specimens are usually examined in a 'hanging-drop' preparation, and this enables the observer to recognise the shape, size, and arrangement of the bacteria present, the presence or absence of spores, and also whether the organism is motile. This method of examination is of the highest importance in dealing with cultures, and should never be omitted. For morbid exudates, pus, etc., it is often unnecessary, and chief reliance is placed on stained specimens. To this end a thin film of the material is spread on a clean slide or cover-glass, allowed to dry, and fixed by being passed two or three times through the flame. This film is then submitted to the staining process, of which there are three chief varieties:

(*a*) *Simple stains,* such as carbol-fuchsin, carbol-thionin, methylene blue, etc., affect all bacteria, as well as the cells, nuclei, etc., of the morbid material. They enable the presence of the bacteria to be recognised, and their shape, size, etc., to be determined.

(*b*) *Gram's Method.*—The film is immersed for three to five minutes in a stain consisting of 10 parts of a saturated alcoholic solution of gentian violet diluted with 90 parts of 1 in 20 carbolic acid in water. It is then treated for two or three minutes with a watery solution of iodine in iodide of potassium (iodine 1, KI 2, water 300), and finally washed in alcohol until no more colour is dissolved out. Some bacteria remain stained when treated in this way, whilst others are completely decolorized.

The following remain stained, and are termed *Gram-positive :* Staphylococci, *Streptococcus pyogenes*, the pneumococcus, the *Micrococcus tetragenus*, the bacilli of tetanus, anthrax, tubercle, leprosy, diphtheria, and the streptothrices causing actinomycosis.

The following lose their stain and are *Gram-negative :* The gonococcus, the meningococcus, the *Micrococcus Melitensis*, the *B. coli*, the bacilli of glanders, typhoid fever, influenza, and soft sore, the *B. pyocyaneus*, the vibrio of cholera, the spirillum of relapsing fever, and the spirochæte of syphilis.

(*c*) *The Ziehl-Nielsen Method.*—The film is stained by means of a powerful stain, usually carbol-fuchsin, which is either heated or allowed to act for several hours. It is then immersed in 20 to 25 per cent. sulphuric acid for five or ten minutes. This removes the stain from all cells, etc., and from the majority of bacteria. A few, however, retain it, and these are called *acid-fast*. Films may also be stained in the same way and subsequently decolorized in alcohol, and organisms which retain the stain are called *alcohol-fast*. Of the organisms which are of importance in human pathology, the bacilli of tubercle and leprosy and a bacillus frequently found in smegma are acid-fast, and the two former are also alcohol-fast. Certain streptothrices are also acid-fast.

(2) It is usually necessary to supplement microscopical examination by *cultural methods* in which a suitable culture medium is inoculated with the material to be examined and kept in an incubator at a proper temperature. These culture media are very numerous, but broth, gelatin, solidified blood-serum, and agar-agar suffice for most purposes. Broth is chiefly used for making vaccines, and for observations on the chemical products of bacteria. Solid culture media are more generally useful, since many organisms form characteristic growths or colonies on the surface or in the depth of the medium. Nutrient gelatin is especially valuable, since it is liquefied by some bacteria, whilst others have no such action; unfortunately, it melts at the temperature necessary for the growth of many pathogenic bacteria, and when this is the case observations on the formation of a peptonizing ferment have to be carried out by cultures on blood-serum coagulated by heat. Agar-agar is not melted at the temperature of the body, and is not liquefied by any organism.

For full details of this method of examination a work on bacteriology must be consulted.

(3) The *inoculation of living animals* is also frequently necessary, in order to prove that an organism which has been isolated in cases

of a given disease is actually the cause of that disease. In the early days of bacteriology, when the bacterial origin of disease was hotly contested, Koch formulated the following postulates, and when these are fulfilled, we may consider the cause of the disease as proved to demonstration:

(*a*) The organism (which must be one that can be definitely recognised from all others) must be present in the body in every case of the disease.

(*b*) It must be possible to cultivate it for many generations apart from the body, thereby getting rid of every trace of the original substance taken from the first case of the disease.

(*c*) The inoculation of a suitable animal must be followed by the appearance of the specific disease.

(*d*) The organism must be found in the animal thus infected.

We do not now demand so rigid a proof of the pathogenic effects of bacteria. Thus, although the *B. lepræ* is universally admitted to be the cause of leprosy, it has never been cultivated, so that with it only the first of Koch's postulates holds. Other tests, such as the presence of specific agglutinins in the blood of cases of the disease, are now applicable.

Inoculation experiments are frequently employed in the practical diagnosis of various clinical conditions. Thus, in examining the morbid products (urine, pus, etc.) of tuberculous affections, the *B. tuberculosis* is often present in such scanty numbers that staining and cultural methods prove ineffective. The subcutaneous or intraperitoneal inoculation of a guinea-pig is an extremely delicate test, and will infallibly lead to the development of tuberculosis if living bacilli are present. The chief drawback is the fact that it takes two or three weeks for the disease to develop.

Inoculations of pure cultures are also often resorted to where the organism present has so close a resemblance to a non-pathogenic form that its recognition is a matter of uncertainty. Thus, several harmless organisms have a close resemblance to the anthrax bacillus, and the latter can only be distinguished by causing anthrax when injected into the lower animals. A refinement on this method, which is applicable in some cases, consists in injecting a normal animal and also an animal immunised against the organism suspected to be present in the culture. Thus, the tetanus bacillus in pus is usually mixed with many other bacteria, so that it is excessively difficult to isolate. A broth culture is inoculated with the pus in question, and incubated in the absence of air, since the tetanus bacillus is an anaërobe. It is then divided into two parts, of which one is injected into a normal animal and the other into one which has received a dose of antitetanic serum. If the former dies and the latter remains alive, the presence of the tetanus bacillus in the culture is certain.

A few micro-organisms other than bacteria require brief mention, but most of them are of little surgical importance.

1. The *yeasts* or *blastomycetes* are devoid of chlorophyll, and multiply by budding, or endogenous spore-formation. They cause many forms of fermentation—*e.g.*, the alcoholic fermentation in solutions of grape-sugar; they occasionally gain access to the urinary bladder in diabetes, and, by leading to the production of irritative products of fermentation, give rise to cystitis. The only important disease now attributed to the yeast-fungi is *blastomycetic dermatitis*, which is characterized by multiple chronic lesions, resembling verrucous tuberculides.

2. The *hyphomycetes*, or filamentous fungi, are characterized by the presence of a mycelial network of long fibres, and have a method of sporulation which is more complicated than that seen in the bacteria or yeasts. The following are the more important of their pathological effects:

Thrush, due to *Oidium albicans*, an organism sometimes included in the blastomycetes, and called *Saccharomyces* or *Monilia albicans*.

Ringworm, which may be caused by *Microsporon Audouini* (the small-spored fungus), or the *Trichophyton* or large-spored fungus, of which there are several varieties. Of these the former is more common in London and Paris, but is rare in most parts of the Continent.

Favus, caused by the *Achorion Schönleinii*.

Pityriasis rubra, due to the *Microsporon furfur*.

Keratomycosis, or parasitic ulcer of the cornea, is due to fungi of the aspergillus type, and similar organisms may also affect the lungs (pneumomycosis) or the external auditory meatus (otomycosis).

The group *streptothrix* may be regarded as the lowest of the hyphomycetes, and its members possess many similarities to the bacteria. They are of importance, since their pathogenic members give rise to the group of diseases known as 'actinomycosis.' The streptothrices form long filamentous hyphæ, which are narrower than those of the higher fungi, and which differ from the leptothrical filaments sometimes exhibited by some bacilli in that they show true branching. They form chain-spores, the protoplasm of the mycelial threads collecting in small masses separated by spaces in which the sheath is empty. These appear to be true spores, since they resist a temperature higher than that which kills the mycelium itself. The streptothrices are widely distributed, and many forms are known, of which but a few are pathogenic.

It is worthy of notice that the tubercle bacillus (as well as other organisms usually classified as bacteria) sometimes grows into long branching filaments. Hence some regard it as belonging to the streptothrices, and term it 'tuberculomyces.'

3. The *protozoa*, or unicellular animals, are a group of considerable importance, since *syphilis* and not a few tropical affections are due to members of this family. The life-history of many of them is not known in its entirety, but it has been traced out in some. Malaria and the amœbic form of dysentery, together with the tropical abscess of the liver associated therewith, are protozoal

in origin. *Trypanosomes* are also of animal nature, and by their development in the body give rise to sleeping sickness and numerous other tropical diseases in man and lower animals.

Infection.

Infection may be defined as the access of living, virulent, pathogenic bacteria to a region whence their toxins may act on the tissues of the body. Certain points in this definition require explanation: (1) It is interesting to notice that dead bacteria, especially dead tubercle bacilli, may cause pathogenic effects quite similar to those of the living ones. This, however, can scarcely be spoken of as infection, since one of the fundamental ideas of that process is that it can be transmitted from one sufferer to another indefinitely. (2) The question of *virulence* is one of the greatest importance, since differing strains of the same organism may vary much in the degree of virulence, as may also the same strain under varying conditions. Thus, rabbits are often but little affected by the injection of large amounts of a pure culture of the *Streptococcus pyogenes*, and yet it is possible so to exalt the virulence of the same culture that an extremely small dose (possibly a single coccus) may produce death. This *exaltation* of virulence is usually accomplished by 'passage' through a series of animals, each in turn being inoculated from the last; the disease appears more rapidly and runs its course more acutely in each instance up to a certain point of maximum intensity, which persists. Probably something of the sort occurs under natural conditions, for an organism taken directly from a patient is usually much more virulent than one that has been cultivated in the laboratory. Thus, a slight post-mortem wound infected from a case of streptococcic peritonitis is usually very severe, indicating a very high degree of virulence in the organism. In general, we know little or nothing of the causes which lead to increase of virulence under natural conditions, and especially so as regards epidemic outbreaks of disease.

Cultures of an organism of diminished virulence are said to be *attenuated*. The artificial attenuation of pathogenic bacteria is a subject of great importance in connection with the production of immunity, and it may be laid down as a general rule that the cultivation of an organism under slightly disadvantageous conditions tends to diminish its virulence, and *vice versâ*. For example, the anthrax bacillus grows best at 37° C., or thereabouts, and retains its virulence for long periods at this temperature, but if it is cultivated at 42° C. it becomes attenuated. Cultures thus treated constitute Pasteur's vaccine against anthrax; when injected into animals they cause transient ill-effects, but the animal becomes immune to the disease.

(3) The organism must be *pathogenic*, if infection is to occur, and by this we mean capable of producing disease in the animal in question. Thus, the inoculation of the gonococcus into the urethra

of animals leads to no results, and infection does not take place. Hence two factors must be present: the organism must be virulent, and the host susceptible.

(4) Lastly, an essential feature of infection is that the toxins of the organism must act on the tissues of the host. Thus, it is quite possible, and not uncommon, for streptococci to be present in the outer layers of the skin, and the *B. diphtheriæ* in the mouth, etc., and yet for no harmful effects to arise, since either the organisms do not form toxins, or else these toxins do not reach the tissues. This is not infection, although in such cases any slight lesion or any condition leading to local or general lowering of resistance may bring it about.

The terms *specific* and *non-specific* as applied to infectious diseases also require explanation. A specific disease is defined as one which is produced by a single cause—*i.e.*, a particular species of microorganism, and by no other. Thus, tetanus is a well-marked pathological entity, always due to the *B. tetani*, and may be taken as the type of a specific infection. Suppuration, on the other hand, is caused by many different species of bacteria, and is therefore termed 'non-specific.' The boundaries of these divisions are constantly changing with the advancement of pathological research. The common process is for diseases which are apparently homogeneous to be split up into specific groups, each due to its own organism. Thus, ringworm is now known to be due to several different forms of fungus, and combined clinical and pathological research have shown that the conditions due to one variety differ in minute points from those due to another. Again, actinomycosis was formerly thought to be a specific disease due to a single organism, but it has now been shown that many organisms may produce it. The reverse process is sometimes seen, several apparently different diseases being united together on the discovery of their cause. For example, malignant pustule and wool-sorter's disease are apparently quite distinct maladies; yet since it has been found that they are both caused by the *B. anthracis* they can now be included as manifestations of one specific disease.

Local Infective Processes are those caused at the site of inoculation by the growth and development of the microbes. After a period of incubation—which varies with different organisms, and during which we may imagine that they are struggling with the germicidal action of the tissues, and establishing their foothold in the body—the bacteria begin to grow and multiply, and by the deleterious products of their activity cause irritation of the tissues and various degrees of inflammation.

These inflammatory foci may remain limited, or diffusion may occur by the bacteria spreading with more or less rapidity by continuity of tissue or along lymph channels; or the organisms may be widely disseminated through the body by the bloodvessels in the shape of emboli. A certain amount of constitutional disturbance may accompany these manifestations, due to the absorption of the toxins produced locally, whilst in some diseases the general toxic symptoms (or toxæmia) associated with some local mischief may be extremely severe, as in tetanus and diphtheria. Hence local infective processes may be classed in two divisions: (*a*) those in which there is but little or no general toxæmia, such as a soft chancre, a tuberculous abscess, or a mild attack of gonorrhœa; and (*b*) those in which the toxæmic condition is well marked, as in erysipelas, tetanus, diphtheria, etc., the character of the symptoms varying necessarily with the different toxins.

Many of the organisms which are the causes of local infection may also develop generally in the system, and produce grave constitutional affections.

General Infective Processes are those in which the organisms develop and multiply in the blood-stream, so that inoculation of a sound person with the blood would almost certainly transmit the disease if a sufficient dose were introduced. Many of the bacteria producing local infection give rise to these general diseases, and, indeed, in surgery we rarely see the latter without some local condition being present to explain its origin. Septicæmia, pyæmia, acute tuberculosis, the second stage of syphilis, anthracæmia, and probably the exanthemata, are illustrations of general infection (see Chapters V. and VIII.).

Immunity.

Under ordinary circumstances every living animal is constantly exposed to possible sources of infection. Bacteria are present in the air we breathe, in our food, drink, etc., as well as on our skins and in our alimentary canals. It is obvious, therefore, that there is some potent natural means of resisting the attack of these organisms, and that it is only when these means break down or are insufficient that infection occurs. This power of resisting the invasion of micro-organisms is termed *immunity*, and it is the exact opposite of *susceptibility*. Further, the process of natural cure of any infective disease is brought about by the production of such a degree of immunity (whether local or general) as shall suffice to destroy the causative bacteria. It is therefore obvious that the study of immunity is of the greatest importance in connection with the prevention and cure of disease, and the more so since the most potent artificial methods of accomplishing these ends are those which imitate, or stimulate, or give free play to, these natural processes.

Natural Immunity is that which is inherent in the constitution of the animal when born, and not due to any event taking place in its life history. Thus the lower animals are all naturally immune to gonorrhœa and many other diseases which affect man, whereas man is naturally immune to many diseases of the lower animals. In most cases natural immunity is general throughout all the members of the species, but this is not always the case; thus, some children are absolutely immune to vaccinia, though the vast majority are susceptible. Hence racial and natural immunity are not quite identical.

It must be clearly understood that there is *no absolute standard* of immunity, since the reaction of the tissues varies from time to time between the highest degree of susceptibility and the highest degree of immunity. Thus, if several animals are inoculated with equal doses of the same bacterial culture, one may show no ill-effects; another may exhibit a slight amount of inflammation at the site of inoculation; a third may acquire a spreading inflammation, which may progress to suppuration or gangrene; whilst a fourth may develop a fatal general infection. Further, an animal may be highly immune to an organism of ordinary virulence, but at the same time highly susceptible to the same organism when its virulence is exalted.

Again, the immunity or susceptibility of any animal to a given bacterium is greatly *influenced by external and internal conditions*. A study of these conditions is of fundamental importance in the prevention of disease. It may be regarded as certain that man possesses a very considerable degree of immunity to nearly all bacteria (including even the tubercle bacillus), and it is only when this immunity becomes lowered by general or local causes which depreciate the vitality that infection occurs.

Of the **general** causes which predispose to infection, *cold* and *wet*, especially if combined, are perhaps the most potent, but the method in which they act is still uncertain. *Starvation* and *malnutrition* are also important, and even in slight degrees have a very decided effect on immunity. Thus, it has long been recognised that post-mortem wounds received when fasting are more dangerous than those received when digestion is in progress. In this case the immunity may perhaps be correlated with the increased number of leucocytes in the blood during digestion, but it does not appear to be a constant fact that a large number of leucocytes always implies a high grade of resistance, and *vice-versâ*. *Age* is an important factor, children being, as a rule, much more susceptible than adults. Immunity is greatly reduced by *hæmorrhage*, and by certain *poisons*, particularly alcohol. Protracted exposure to a *vitiated atmosphere* is a very potent factor in the production of susceptibility to the tubercle bacillus. *Prolonged anæsthesia* lowers the general resistance of the body, as also certain diseases, notably *Bright's disease* and *diabetes*.

The **local** causes include *injury*, especially *bruises, contusions, burns*, and the *irritation due to chemical substances*. This latter condition is often used in the laboratory to exalt the virulence of certain bacteria. Thus, pyogenic cocci are often without effect on rabbits, even in tolerably large doses; but if injected together with some dilute lactic acid, the toxins of other bacteria (such as *B. prodigiosus*), or other soluble irritant, they are frequently enabled to develop and produce pathological results. Considerable surgical importance is attached to this observation, since it must not be forgotten that nearly all antiseptics are irritant, and if applied in too concentrated a state or for too long may lower the local resistance, and render the wound more liable to be infected by any organism that may at the time or subsequently gain accidental entrance. The local application of *cold or hot liquids* has a similar action, and hence all fluids used to wash out wounds or body cavities should be used exactly at blood heat, unless the direct effect of the heat or cold is required. Lastly, a *defective supply of fresh blood*, due to disease in the bloodvessels, or *stagnation of venous blood* due to tight bandaging, pressure, etc., also renders a part less resistant to infection.

Acquired Immunity is of two kinds—active and passive.

Active immunity results from a previous attack of the disease, either natural or due to artificial inoculation, so that the individual is freed from the risk of contracting it again. Syphilis and the exanthemata are good illustrations of diseases conferring an active immunity, which, however, is not always absolute, since well-confirmed examples of second attacks, even of syphilis, have been recorded. On the other hand, it is doubtful whether tuberculosis and the pyogenic diseases are capable of producing immunity.

The following are the most important artificial methods of bestowing active immunity: (1) Inoculation of the disease as it occurs in nature. This is of course a dangerous method, since the attack is almost as severe as one acquired in the normal way. It was formerly practised as a preventive of small-pox before the introduction of vaccination. (2) Inoculation with the virus of the disease or its causal micro-organism in an attenuated condition. Vaccination is the best example of this process; the lymph employed is a culture of the small-pox organism (the exact nature of which is at present not definitely known) in a state of diminished virulence. Pasteur also applied the same method in the prevention of hydrophobia (p. 140) and of anthrax in cattle, the 'vaccine' in the latter case being a living culture of anthrax bacilli attenuated by being cultivated at a temperature of 42° C. (3) Injection of dead cultures of bacteria is used in the preventive inoculation against plague (Haffkine) and against typhoid fever (Wright). The cultures are killed by heat, and small doses injected subcutaneously. The result is a local inflammatory reaction of varying severity, together with general symptoms, such as fever and malaise. When these have passed off, the patient has acquired some immunity to the disease, so that he is now able to withstand the injection of a larger dose or even of a living culture, by which means the immunity is greatly increased. Koch's tuberculin (TR) is of a similar nature; it consists of an emulsion of finely comminuted tubercle bacilli which have been killed by a process of grinding. This method has now been extended to the cure of many other infective conditions. (4) Injection of the extracellular toxins of the causative organism is not used in man, but it is of the utmost value in immunizing the lower animals for the preparation of curative sera, especially antidiphtheritic and antitetanic. The horse is chosen for this purpose, since it is easy to handle, and yields a large amount of serum at each bleeding. The principle of the method is simple. A small quantity of the toxin (which has been filtered to remove living bacteria) is injected subcutaneously. It causes local inflammation, fever, and malaise; but when these have quite subsided, another and slightly larger amount of toxin can be tolerated. In this way the dose is gradually increased, until the animal is so resistant that the injection of enormous doses of most powerful toxin will produce but slight and transient ill-effects. In actual practice this method is usually modified, the earlier stages being considerably shortened by the injection of a mixture of toxin and antitoxin, or by the use of peculiar forms of toxin of diminished activity.

It will be noticed that in all these methods the animal which subsequently becomes immune combats with and overcomes the organism or its toxin, and is always rendered more or less ill (in some cases very slightly) by the process. For this reason it is termed an active immunity—*i.e.*, it is acquired by the animal's own active combat with and victory over the disease.

Passive immunity is that which is conferred on an animal without effort on its part by the injection of serum from an animal that has already acquired an active immunity against the disease in question. For example, if some of the serum from a horse which has been actively immunized against tetanus is injected into a second horse (or other animal), the latter will also become immune to the tetanus bacillus or to its toxin. The second animal is not rendered ill by the injection, and is merely the passive recipient of protective substances which have been elaborated by the first. The fact that the injection of these sera into man sometimes causes transient ill-effects, such as fever, joint-pains, rashes, etc., in no way modifies the truth of this statement: the phenomena in question do not always occur, and may be due to other causes (p. 28).

Passive immunity cannot be bestowed by the injection of serum from an animal which is naturally immune: most of the lower animals, for example, are naturally immune to syphilis, but their serum has no protective or curative action in man. The diseases in which the serum has the greatest practical value for protection or cure are those in which the specific micro-organisms produce extracellular toxins, especially diphtheria and tetanus.

Active and passive immunity also differ in other respects. Passive immunity is produced immediately the serum is injected, whereas active immunity is only developed slowly after the injection of the toxin, or of the living or dead culture; in general, a week at least must elapse before the full degree of immunity is produced. Again, passive immunity lasts a comparatively short time, unless, of course, the dose of the immunizing serum is repeated. In the case of a prophylactic injection of antidiphtheritic serum in man, the duration of the immunity is about a couple of months.

Active immunity is usually much more lasting, though its duration varies greatly in different cases. In most cases of syphilis and small-pox it is permanent, second attacks being extremely rare, whereas in pneumonia and erysipelas it is of very short duration.

When we turn to the **theories** which have been promulgated to explain the facts briefly outlined above, it must be borne in mind that there are two groups of phenomena which require elucidation: the immunity to the bacteria and the immunity to their toxins. Thus, if a culture of living diphtheria bacilli is injected together with their toxin into a susceptible animal, the bacilli will continue to grow in its tissues, and the toxin will exert its poisonous effects, both local and remote. If the same culture is injected into an immune animal (whether the immunity is natural, active, or passive), the bacteria will be killed and the toxin will have no action. This bacterial immunity must first be discussed.

Omitting theories which are merely of historical interest, we come first to the *humoral theory*, which asserts that the destruction of the bacteria is due to certain substances which are present in the blood, lymph, etc., and which are designated *alexins*. The experimental foundation for this theory consists in the fact that fresh blood, and more especially fresh blood-serum, has very considerable bactericidal action. This action is destroyed if the serum is exposed to heat (about 60° C. for half an hour), and disappears spontaneously after a day or so; when the alexins have been destroyed by either process, the serum becomes an excellent culture medium for most bacteria.

Metchnikoff's theory of phagocytosis (the *cellular theory*) was at first in strong opposition to the humoral theory, but subsequent researches have brought the two closer together. Starting from the fact that unicellular protozoa (such as the amœba) ingest, digest, and assimilate the bacteria found in water, Metchnikoff was led to examine the action of the leucocytes, or wandering cells of the higher animals, which in their morphology so strongly resemble the lower protozoa, and found in them a similar power of engulfing and digesting living micro-organisms. This process he termed *phagocytosis*. A striking example occurs in Daphnia (the fresh-water flea), an animal which is so transparent that the whole phenomenon can be followed under the microscope during life. It is affected with a disease due to the growth in its tissues of a fungus known as Monospora. The spores of this parasite are taken in with the food, and penetrate from the alimentary canal into the body cavity; when unchecked, they continue to grow until the whole animal is filled with growth. If, however, but few spores gain access, the defensive mechanism comes into play, and the spores are surrounded and engulfed by the leucocytes, submitted to a process of digestion, and finally destroyed. It is obvious that Daphnia is partially immune to Monospora, and that the immunity depends on the phagocytic activity of its leucocytes. Metchnikoff had no difficulty in finding many examples of the same process in man and the higher animals. If, for instance, a culture of a non-pathogenic organism is injected into the peritoneal cavity of an animal, and portions of the peritoneal fluid are examined from time to time, the bacteria will be seen first lying free; then engulfed in the protoplasm of the leucocytes, but retaining their normal appearance and staining reactions; then less distinct and refractile than before, indicating that they have undergone partial digestion, and in this state they stain badly. Similar appearances may also be seen in sections of tuberculous tissue, especially those that are healing, though here the phagocytic cells are not leucocytes, but endothelioid or giant cells.

The leucocytes are attracted to the region of the bacteria owing to the fact that the latter give off soluble substances for which the leucocytes have an affinity, so that they move into the region in which these substances exist in a high state of concentration. This process is known as *chemotaxis*, and it is one which is widely distributed throughout the lower members of the animal and vegetable kingdoms. If, for instance, a capillary-tube filled with meat-extract is placed in a watery emulsion of typhoid bacilli, the latter will be attracted by chemotaxis and enter the tube. Similar phenomena are seen in the formation of an abscess: the pyogenic bacteria give off substances which attract the leucocytes, so that they soon become surrounded by a zone of these cells, and at the same time some of these substances gain access to the blood and attract the leucocytes from the bone-marrow, giving rise to a general leucocytosis.

Metchnikoff found that in cases where phagocytosis was active recovery usually took place, and that when it failed the bacteria continued to grow and death occurred; from this he argued that immunity depends entirely on the leucocytes. He further noted that in animals with acquired immunity the leucocytes had gained the power of ingesting the bacteria, although previously unable to do so; hence he explained acquired immunity as being due to the education which the leucocytes had gained during the previous attack. The opponents of the theory urged that only dead, or at least non-virulent, bacteria were taken up by the cells, but Metchnikoff's great technical skill enabled him to isolate bacilli that had been actually ingested by leucocytes and prove them to be living and virulent.

The theory of phagocytosis was never generally accepted in its original form, and it was soon found not to apply in certain cases. Thus, it is possible to enclose active bacteria in a collodion sac, which will allow the transudation of body fluids, but will prevent the passage of leucocytes; if such a contrivance is placed in the peritoneal cavity of an immune animal, the bacteria are often killed. Further research also showed that even when bacteria are ultimately destroyed by phagocytic activity they may lose their definite outline, refractility, etc., and give other indications of being injured whilst still free and extracellular. The fact that this extracellular injury or destruction usually occurs when the bacteria are surrounded by leucocytes led to the theory that the alexins are formed from or secreted by the leucocytes. This is the *cellulo-humoral theory*, and it may be regarded as a compromise between the two views enunciated above. It agrees with the humoral theory in regarding the destruction of the invading bacteria as due wholly or partly to soluble substances present in the body fluids; and with the cellular theory in attributing to the leucocytes the paramount rôle in the defences of the body, but differs from it in allotting to them a double action, partly chemical and partly phagocytic.

Many facts go to prove that there is much truth in this compromise, but it is not a complete explanation. Thus, Behring's investigations on the subject of passive immunity, especially in connection with diphtheria, introduced a new element and opened up a fresh field of research. It was found possible to cure the disease by a suitable serum or antitoxin which has no bactericidal effect whatever, so that its activity cannot be attributed to alexins or other bactericidal substances.

Metchnikoff explained its practical value by attributing to it the power of stimulating the leucocytes to more vigorous phagocytic action; but this view can no longer be sustained, though, as we shall see, it has a substratum of truth. Further researches showed that the action of the antitoxin is an extremely simple one. It unites with its specific toxin, and forms a compound which is devoid of toxic properties. It is unnecessary to give the full evidence on which this statement is based, but one single proof may be mentioned. Several bacteria—amongst others the tetanus bacillus—produce toxins which have the power of dissolving red blood corpuscles (hæmolysis); hence these substances are called the bacterial hæmolysins. Experiments on hæmolysis can be carried out *in vitro*, and it is thus possible to avoid all complications arising from phagocytosis or the action of the living tissues. Now it is found that tetanus antitoxin will prevent the hæmolytic action of the hæmolysin of the tetanus bacillus in the test-tube as well as in the body. Here, therefore, there must be merely a simple process of chemical neutralization, which may be compared with the action of an alkali on an acid.

The discovery of the antitoxins for diphtheria and tetanus led to numerous attempts to form similar substances for other poisons. It was found impossible to produce antitoxins for the alkaloids, mineral poisons, etc. Antitoxins were, however, prepared for snake-venom, eel-serum, abrin, ricin, etc., and for some other bacterial toxins. These poisons have these factors in common: they are all formed in living organisms, whether animal or vegetable, and they are all proteids or closely-allied substances.

The *method of action of the antitoxins* throws a certain amount of light on the mechanism of some forms of immunity. It has no bearing on natural immunity, for the blood of an animal which is naturally immune, say, to tetanus, does not contain tetanus antitoxin; but in recovery from tetanus the antitoxin appears in the blood. When this happens, any fresh toxin that the bacilli form will be immediately neutralized, and the latter will thereby be deprived of their power to injure the cells of the animal, and can be dealt with by phagocytosis or other means. In the production of passive immunity similar phenomena take place; the antitoxin artificially injected in the blood combines with the toxin and shields the cells from its action.

But this still leaves the *method of formation of these antitoxins* unexplained. Several theories have been advanced to account for this phenomenon, but the only one of importance is *Ehrlich's side-chain theory*. It is somewhat complicated, but the brilliant way in which it accounts for the chief facts, and its profound influence on modern ideas of pathology, justify a brief outline of its more important features.

A toxin possesses two properties, that of poisoning a cell and that of combining with antitoxin, and Ehrlich proves that these two functions reside in different portions of the molecule. To the part that unites with antitoxin he gives the name 'haptophore,' whilst the toxic portion is termed the 'toxophore.'

Ehrlich next assumes that a molecule of living protoplasm may be considered as consisting of two parts. One discharges the function of the cell of which it forms part, whilst the other subserves the nutrition of the former more highly differentiated portion, and has the power of uniting with molecules of proteid dissolved in the blood or lymph, and then building them up into living protoplasm. This function is supposed to be accomplished by side-chains, or specialized portions of the cell, which unite with the molecules of food proteid. It is assumed that these latter contain a haptophore group similar to that of a molecule of toxin, but no toxophore group; so that the first step in the nutrition of the cell consists in the union of a side-chain with the haptophore group of a molecule of proteid, a process which Ehrlich compares with the seizure of particles of food by the tentacles of a sea-anemone. Further, there are many varieties of proteids in the blood, and the molecules of each of these must have their own peculiar haptophore groups. Each haptophore group must 'fit' a side-chain (like a key fitting a lock), or it will be useless for nutrition.

In applying this view to the action of a toxin, it must be remembered that the toxins are proteids or similar substances. If we inject a solution, *e.g.*, of tetanus toxin into an animal, it may happen that the side-chains carried by the animal's cells do not possess haptophore groups which 'fit' those of the toxin; in this case no poisoning can occur, as the toxin cannot unite with the cells. If the cells do possess such side-chains, they will unite with the haptophore of the toxin, just as if these side-chains had seized a nutritious molecule. The toxophore radicle is thus brought into action, since it is united to the cell by means of the haptophore group and side-chain. Presumably it exerts an injurious influence similar to that of an enzyme, and the integrity of the functionating part of the protoplasmic molecule is thereby destroyed. In other words, the first step in the intoxication of a cell by a true toxin is exactly the same as the first step in cell-nutrition.

Suppose, now, that a certain number of the side-chains are fixed to molecules of toxin, and that the living molecule is injured, but not fatally. The side-chains are necessary for the nutrition of the cell, and those that are rendered useless must be regenerated, just as a hydra replaces a lost tentacle. If a second dose of toxin is given this process is repeated; and if we continue to administer toxin in suitable (non-lethal) doses, we may gradually 'train' the cell to produce side-chains more and more rapidly. But *it often happens that the reaction of a living tissue is much greater than the stimulus demands ; e.g., the formation of callus is disproportionate to the amount of bone to be replaced. This may be presumed also to happen in the production of antitoxins. The cell produces more side-chains than it has any necessity for—more, indeed, than can* *remain united with it, and the superfluous ones detach themselves from the cell and float off in the blood. They still retain their power of uniting with the haptophore group of a toxin molecule, thereby rendering the toxin inert, and thus they constitute antitoxin.*

It is impossible to discuss here the evidence that has been brought forward in support of this theory, but one remarkable point may be noticed. For a cell to be poisoned by a given toxin, it is necessary that it should contain side-chains which ‘ fit ’ the haptophore group of that toxin. But antitoxin consists of such side-chains, so that it follows that any cell which can be poisoned by a toxin may be made to produce an antitoxin to it. There is evidence that this is the case in tetanus, the toxin of which (tetano-spasmin) acts only on the cells of the central nervous system. It was found by Wassermann that an emulsion of the gray matter of the brain has the power of neutralizing tetanus toxin just as antitoxin has, but that this power is lacking from emulsions of other tissues. Thus the cells of the central nervous system are the only ones which have side-chains that can unite with the tetanus toxin.

Again, it would not be surprising if some of these side-chains were to break off and pass into the blood under natural conditions. This actually happens, for traces of antitoxins (and other ‘ antibodies ’) frequently occur in normal blood.

Ordinary chemical poisons do not give rise to the formation of antitoxins, since they do not unite especially with the side-chains as if they were nourishing proteids, but form chemical combinations with all parts of the molecule indiscriminately.

It was soon found that substances allied to antitoxin might be obtained by the injection of proteid substances other than toxins into living animals. These are known as **antibodies,** the term being used to include precipitins, agglutinins, cytolysins, bacteriolysins, etc.

Precipitins are substances formed by the injection of proteid solutions, and have the property of forming a precipitate when mixed with a solution of the same proteid as was injected. Thus, if a solution of egg albumen is injected into a rabbit, the serum of this animal (after a week or so) will give a flocculent precipitate with egg albumen, but not with other proteids. The precipitins are not known to have any bearing on the question of immunity, except in that they form an example of the general law that if any foreign proteid is injected into a living animal it gives rise to the production of an antibody.

Agglutinins are formed by the injection of bacteria, red blood corpuscles, cells, etc., and they have the power of causing the cells injected to collect into clumps. A special case of great importance is in typhoid fever, where the agglutinin is formed early in the disease and is of diagnostic value (*Widal's reaction*). In most infections this is not the case; thus in pneumonia the serum rarely shows any power to agglutinate the pneumococcus before convalescence is established. They are, however, of value in that they often enable the bacteriologist to prove the causal relationship of an organism and the disease it is supposed to produce. Thus in the investigation of the pathology of dysentery various organisms are isolated from the stools, and if one of these is found to be clumped powerfully by the patient's own serum, it affords strong proof that it is really the infective agent. The agglutinins are also useful as proving the identity of an organism which has been isolated in culture. For example, if a culture of an organism resembling the typhoid bacillus had been isolated from the stools in a case of suspected typhoid fever (or from drinking-water, etc.), the first test applied to establish its nature would be to see if it clumped with the serum of an animal which had been injected with a known culture of typhoid bacilli. Agglutinins are not known to play any part in the production of immunity, and their presence in the blood does not necessarily indicate that the animal is immune, though this is usually the case.

The next group of antibodies—*cytolysins* (including the *bacteriolysins, hæmolysins,* etc.)—are of great importance in the doctrine of immunity, and are much more complex in their structure and action than the preceding. The earliest indication of their existence was obtained by Pfeiffer, who immunized guinea-pigs to the cholera vibrio, and when the immunity was fully established injected a culture of that organism into the peritoneal cavity. Some of the peritoneal fluid was withdrawn from time to time, and the organisms therein examined microscopically. They were found to undergo remarkable changes, losing their shape, becoming spherical, and finally undergoing complete solution; the whole process often takes half an hour or so. This is called *Pfeiffer's reaction*, and is specific —*i.e.*, the peritoneal fluid of an animal vaccinated against cholera has no effect on the typhoid bacillus or any organism other than the cholera vibrio or its congeners. Further research showed that the reaction can be obtained *in vitro*, provided that the peritoneal fluid is perfectly fresh; if, however, the fluid is kept a day or two, it loses this power, but regains it if mixed with perfectly fresh serum, whether this be taken from a normal or from an immunized animal. Thus:

Fresh normal blood serum + cholera vibrios = no reaction.
Fresh serum (or peritoneal fluid) from immunized animal + cholera vibrios = solution.
Stale serum from immunized animal + cholera vibrios = no reaction.
Stale serum from immunized animal + fresh serum from normal animal + cholera vibrios = solution.

It is obvious from this that *two* substances are necessary for the solution of the organisms in the tissues of an immunized animal. One occurs only in the fluids of the immunized animal, not in a normal one, and is an antibody similar to the agglutinins, but more complex; it has received many names, and is usually known as *amboceptor*, or *substance sensibilatrice*. The other occurs in normal blood, as well as in the blood of the immune animal, and is very fragile, rapidly disappearing when the fluid is kept; it is also readily destroyed by heat. It is probably the same as the alexin referred to above in connection with the humoral theory of immunity, but German writers usually term it the *complement*.

Further research on the antibodies of this group has been greatly facilitated by Bordet's discovery of the production of hæmolysins by the injection of blood from one animal into another of a different species. Thus, rabbit's serum is without effect on the red corpuscles of a horse; but if the rabbit is injected with a horse's red corpuscles, its serum acquires the power of dissolving or hæmolyzing them. These hæmolysins apparently act in exactly the same way as do the bacteriolysins in Pfeiffer's reaction, and are much more convenient for experimental purposes. Further, it appears that the reaction is a general one, and that cytolysins can be prepared for spermatozoa, liver and kidney cells, cells of the central nervous system, etc., and that in each case the reaction depends on a stable antibody or amboceptor and a labile ingredient of normal blood, the complement or alexin.

In applying these facts to the production of acquired immunity—*e.g.*, to the immunization of an animal by injections of small doses of cholera vibrios—it must be noted that the organism at first continues to grow in the tissues; the only known force capable of opposing it at this stage is the action of the phagocytes, for the alexins or complements are unable to act, since they cannot unite directly with the bacteria, and there is no amboceptor. After a time the cells of the host begin to form antibodies to the proteids of the bacterial protoplasm. Some of these may be antitoxins, which prevent the further intoxication of the animal; others are agglutinins, which are without known value to the host; lastly, there are amboceptors which link the alexin or complement of the blood to the bacteria, and bring about the solution of the latter. The animal is now immune, and when any further invasion with cholera vibrios takes place the apparatus of amboceptor and complement is ready for the defence of the animal. Further, the serum of the animal contains amboceptor, and when injected into a second animal this acquires passive immunity, provided that a suitable alexin is also present. This is one of the practical difficulties which prevent the successful application of the bacteriolytic sera in medicine. The alexin present in the serum of the immunized animal soon disappears, and although an amboceptor which is formed in the blood of one animal is always capable of being 'activated' by the complement of the same animal, it cannot necessarily be activated by the complement of other animals. This question is one which is extremely complex, and is at present not thoroughly investigated, though we can hardly hope for any further advance in serotherapy until it has been elucidated.

The rôle of the leucocytes now acquires fresh interest. We have already seen reason to believe that alexin is derived from these cells, and some hold that they are also the main source of the production of amboceptor and the other antibodies. The study of these latter substances has afforded a further insight into the function of phagocytosis. It was found (by Mennes) that leucocytes from a normal animal had no power of ingesting virulent pneumococci, but that they acquired this power when mixed with the serum of an animal which had been immunized to pneumococci. It is thus evident that immune sera have the power of aiding the action of the leucocytes, presumably in virtue of containing an antibody which unites with the bacteria and renders them vulnerable. The antibodies which act in this way might be antitoxins, amboceptors, etc., but it is possible that they may be fundamentally different. Sir Almroth Wright, who has done much in elucidating this field of work, terms them *opsonins* (from *opsono*, I cook, or prepare for food), and holds that the amount which is present in the blood determines the degree of immunity to various infections. That they act directly on the bacteria may be proved thus: Bacteria are mixed with fresh serum, and the latter removed by centrifugalization, and the organisms freed from all traces of serum by repeated washings with normal saline solution. Bacteria thus treated are taken up by the leucocytes as readily as if the serum were still present, from which we infer that they have retained some element of the serum which has sensitized or prepared them for phagocytosis. It is, of course, possible that the serum may also act directly on the leucocytes, stimulating them to greater activity, but there is no proof of this.

These substances have recently been the subject of much investigation, both from the clinical and scientific aspects. There is, of course, no method by which the amount present in a given sample of serum can be estimated quantitatively, but Wright has devised a process by which the quantity in two specimens can be compared. Thus it is possible to count the number of individual bacteria of any particular type which can be ingested by washed healthy leucocytes when mixed with a patient's serum, and the number ingested by similar leucocytes mixed with the serum of a known healthy individual, the two mixtures being kept at the body temperature for the same period of time. The ratio between these two numbers is termed the *opsonic index*. The test is carried out by preparing two mixtures in separate long capillary pipettes. The first contains equal parts of washed corpuscles, bacterial emulsion, and the patient's serum; the second, equal parts of washed corpuscles, bacterial emulsion, and the healthy serum. The contents of each pipette must be well mixed. The two pipettes are then incubated for fifteen minutes at body temperature. Films are prepared from each mixture, suitably stained, and examined microscopically; the leucocytes will be found to have ingested a certain number of the bacteria (Fig. 7). A careful count is now made of the number in 50 or 100 leucoyctes in each preparation, and the ratio between the totals determined. Thus, if in the preparation containing the normal serum there were 240 organisms (*e.g.*, tubercle bacilli) in 100 leucocytes, and in the other only 120, the opsonic index would be $\frac{120}{240} = 0{\cdot}5$, showing that the patient's serum contained much less of the opsonin to the tubercle bacillus than did that of the healthy person. In practice the process is a difficult one, and many precautions are necessary if accurate results are to be obtained.

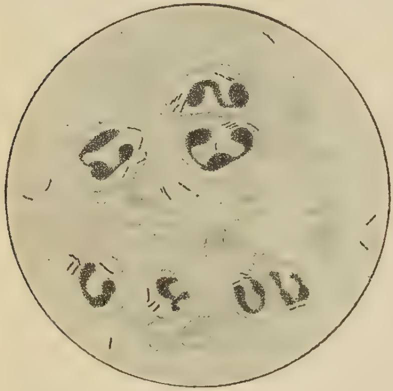

Fig. 7.—Phagocytosis of Tubercle Bacilli in Opsonin Preparation. (Emery.)

Opsonins are delicate substances, which disappear on keeping, and are readily destroyed at moderate temperatures (60° C. or less), closely resembling the alexins in this and some other respects. They appear to be specific (though this is disputed). A patient may have a high opsonic index to one organism and a low one to another.

Healthy persons approximate closely to one another in their opsonic indices. In the case of the tubercle bacillus it is rare to find a non-tuberculous patient with an index above 1·2 or below 0·8, and in a doubtful case a figure decidedly above or below these limits is very suggestive of tubercle. The diagnostic value of this test, however, is diminished by the fact that many tuberculous patients have normal indices. As a general rule, in cases of acute diseases, it is found that the index is below normal, and that as recovery occurs it rises to or above the healthy level. This rise may be sudden, as in most cases of pneumonia, or gradual, as is usually the case in furunculosis. It is not uncommon to see patients in whom the disease is progressing though the index is high, and this is especially the case in tubercle.

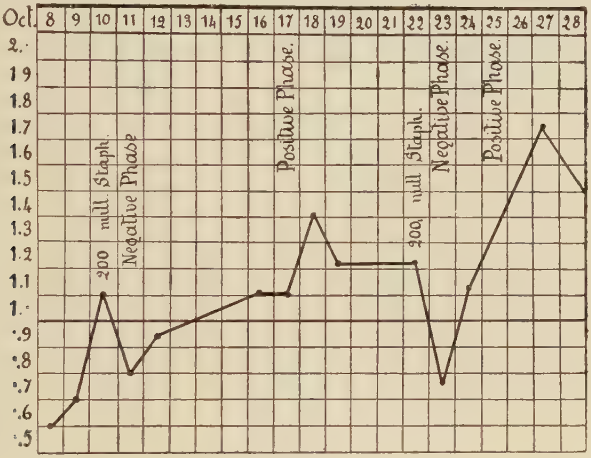

FIG. 8.—CHART OF OPSONIC INDEX IN A CASE OF INJECTION OF A STAPHYLOCOCCIC VACCINE.

It is too early to form a definite opinion of the importance of the opsonins in immunity. There can be no doubt that they play some part, but they are not the sole agents; and their importance has certainly been exaggerated by many authorities. In some respects their discovery has rendered the phenomena of immunity still more difficult of comprehension.

Wright has put the study of the opsonic index to practical use in the regulation of the dosage of his vaccines (Fig. 8). After each injection there is a rapid fall in the opsonic level (the negative phase), followed by a rise, the index usually going well above normal (the positive phase). The improvement is supposed to coincide with and be due to the increased amount of opsonin in the blood, and when this begins to diminish, a fresh injection is given. A second injection should not be given during the negative phase, since if this is done the index falls still further, and it is held that danger (of dissemination or rapid spread of the disease) might arise

Wright therefore controls his injections by periodical examinations of the opsonic index, determining the dose which gives the maximum rise, and giving a fresh injection as soon as the effect begins to wear off.

The experience of the past few years has, however, shown that the frequent and laborious estimations of the opsonic index are really unnecessary, and the majority of practitioners dispense with them in the more simple cases, relying for the recognition of the good or bad effects upon the clinical results—*e.g.*, diminution of fever, discharge, or pain, commencing healing of the wound, etc. Where this fails, opsonic control should be resorted to, as also when dealing with internal infective processes, especially if acute and dangerous, and particularly in septicæmia and basic meningitis.

The practical applications of these researches and theories of immunity are twofold—diagnostic and therapeutic. The chief examples of their *diagnostic application* are the agglutination reaction, as used in Widal's test (p. 21) in the diagnosis of typhoid fever and to a less extent in other diseases, Wassermann's reaction in syphilis (p. 153), and the employment of the opsonic index.

The *therapeutic applications* are more important, though there is still much to be done before their practical use is fully understood. The substances employed in artificial immunization, and in the curative treatment of disease, fall under three main headings:

1. **Vaccines,** using the term more especially in reference to the emulsions of dead bacteria referred to on p. 15. As used curatively, they are prepared as follows: The organism is obtained in a pure condition from the patient to be treated, and a young culture is emulsified with sterile normal saline solution, and sterilized by being heated in a sealed test-tube to a suitable temperature—*e.g.*, 60° C. for half an hour. The number of bacteria per cubic centimetre is then ascertained (there are several methods by which this can be done), and the emulsion diluted with a sterile 0·25 per cent. solution of lysol or carbolic acid in normal saline solution. The degree of dilution has, of course, to be determined by the strength of the original emulsion, and by the number of bacteria which it is desired to administer in each dose. This varies greatly with different organisms; thus staphylococci and gonococci are usually tolerated in large doses (500,000,000 or more), whereas *B. coli* in large doses causes severe local and general symptoms, and the number given should be much smaller. As a rule, too, the patient acquires some degree of tolerance, and the dose may often be slightly increased as the treatment progresses.

It is always advisable, where practicable, to prepare the vaccine for each patient from the organism which is attacking him (autogenous vaccine), since there are minute differences between the various strains of bacteria, and a ready-made vaccine may not prove efficacious against an infection with, apparently, the same species. This is less important in the case of the staphylococci, more so in dealing with the streptococci and *B. coli*. As, however, the vaccine takes a few days to prepare (having to be tested for sterility), it is often a good plan to commence the treatment with a small dose of a stock vaccine.

At present the use of vaccines must not be looked upon as replacing surgical treatment, but as an adjunct thereto. Abscesses must be opened and drained, dead bone removed from the bottom of a sinus, etc., just as before, but the use of a suitable vaccine may often greatly aid the process of healing and shorten the convalescence. In cases which are not amenable to surgical treatment, or in which the surgeon desires to wait for a time before operating, this treatment should be tried whenever possible. Boils, however, may often be aborted in a most striking manner by an injection of 250,000,000 to 500,000,000 staphylococci.

2. **Antitoxic Sera** are the antitoxins to tetanus, diphtheria, and possibly, to some extent, dysentery. These, as has already been explained, contain substances which neutralize the extracellular toxins of the organisms in question: the problem of preparing potent antitoxins for the intracellular toxins has not yet been solved. The main point to notice in the use of antitoxic sera is that they will render the toxins inert, provided that they are brought in contact therewith before the latter have combined with and injured the living cells; hence the importance of their early administration. Time may also be saved by intravenous injection, since it has been found that diphtheria antitoxin is not fully absorbed from the subcutaneous tissues for twenty-four hours or more. The process is simple. The serum is warmed to body-heat and sucked into an all-glass syringe (carefully sterilized). The skin over a large vein of the forearm is prepared as for an operation, and the vein itself rendered prominent by obstructing the circulation by gentle pressure with the finger. All air is removed from the syringe and needle, and the latter introduced obliquely at the side of, and about $\frac{1}{4}$ inch from, the distended vein. It is pushed gently in until the vein is entered, when the blood will rise into the syringe. As soon as this happens, the finger which is obstructing the vein is removed, the piston pushed gently down, and the antitoxin forced slowly into the circulation. There is less object in administering the serum by this method in tetanus than in other cases; but even here the first dose may be given in this way with advantage.

3. **Other Sera.**—These act bactericidally (from containing amboceptor), or perhaps facilitate phagocytosis. They are not, as a rule, so potent curatively as are the antitoxic sera, but, where these and the vaccines are not available, must be given a trial. The sera most important in surgical practice are:

(*a*) *Anti-streptococcic Serum.*—This is prepared by immunizing horses with living cultures of *Streptococcus pyogenes.* This organism is found to present marked differences in cultures from various sources; and since it is held that a serum prepared against one variety is useless against another, *polyvalent* sera are prepared by treating horses with cultures from many sources, and should always be used if possible. If no noticeable benefit follows shortly after the first dose, it is advisable that the second should be from a different laboratory, as one serum may be efficacious in one case and another in a different one. If there is marked improvement, especially a fall in the temperature, the serum should not be changed. A transient rise of temperature (due, possibly, to solution of the streptococci and liberation of their toxins) is not necessarily a bad sign, and is often followed by marked improvement. The dose may be 10 to 20 c.c., or even more.

(*b*) *Anti-anthrax Sera,* of which the best known in this country is that prepared by Sclavo. This has given excellent results in the treatment of localized anthrax (malignant pustule), and the improvement is often manifested within twenty-four hours.

(*c*) *Anti-pneumococcic Serum* (Pane's or Römer's) may be tried in severe pneumococcal infections, more especially in septicæmia and peritonitis, and in some cases seems to act well. Good results have also been obtained in pneumococcal ulceration of the cornea (ulcus serpens).

There are numerous other sera, which do not call for notice.

Serum Disease.—It sometimes happens, especially if the patient has received large doses of antitoxin, that a remarkable series of phenomena take place after an incubation period of eight to twelve days or more. The chief are fever; a skin rash (urticarial, scarlatiniform, or morbilliform), usually accompanied by severe itching; enlargement of the lymph-glands, corresponding to the site of infection; pains in the joints, especially the metacarpo-phalangeal, wrist, and knee; and leucocytosis. Though unpleasant, the symptoms are not dangerous, and recovery usually occurs in a few days. Calcium lactate, in 15-grain doses at the time of the injection and for a day or two subsequently, diminishes the frequency with which the disease develops, and constitutes the best treatment for it when developed.

Anaphylaxis is a condition of supersensitiveness to certain proteid substances, such as serum, egg albumen, bacterial toxins, etc., set up in the body by their injection. It may follow one injection, or may require several in order to determine its occurrence. Thus, if a subtoxic dose of horse serum is injected into an animal, and a second subtoxic injection be made after a suitable interval, the second injection may be followed by marked toxic or even fatal symptoms. About eight to twelve days is usually the minimum necessary to establish anaphylaxis, and the condition may persist indefinitely. Thus, a patient with sarcoma of the ileum had been treated repeatedly and with much benefit by injections of Coley's fluid. After a somewhat prolonged interval he was again submitted to an injection of half a minim of the fluid. The result was a febrile attack of great intensity lasting for over a week, with a temperature of 104° F., which only gradually subsided to the normal. Nothing definite is known of the cause of this phenomenon, and the treatment is merely symptomatic.

CHAPTER II.

INFLAMMATION.

'INFLAMMATION is the succession of changes which occur in a living tissue when it is injured, providing the injury is not of such a degree as at once to destroy its structure and vitality.' Such was the definition given in 1870 by Burdon Sanderson, and it is sufficiently accurate if we realize that the exciting injury usually involves the admission of a soluble chemical irritant, and in most cases of a bacterial toxin; we must also exclude from the process of inflammation the later stages of repair. Formerly inflammation was looked on by pathologists as always of a destructive and harmful nature; but at the present time bacteriological research has demonstrated that, if it can be suitably controlled, it is rather of a protective or conservative character, being Nature's means of limiting the advance of noxious micro-organisms, and of finally eliminating them from the system. Occasionally, however, the tissue reaction called into existence by bacterial invasion is so severe as to increase, rather than diminish, the risks of the patient, who may, moreover, be destroyed by absorbing virulent toxic bodies produced by the bacteria.

The **causes** of inflammation are varied and numerous. Most frequently it is due to the admission of bacteria, and we have already alluded (p. 14) to the conditions, local and general, which predispose an individual to such invasion, and render him more liable to an inflammatory attack. Apart from bacteria, inflammation may be lighted up by (*a*) mechanical lesions, such as blows, sprains, tension, pressure, etc.; (*b*) burns or scalds; (*c*) toxic bodies, such as acids, alkalies, or vegetable and animal poisons; and (*d*) the electric current, either in the form of lightning, or as applied by the surgeon or through the agency of strong currents as employed for purposes of traction or illumination. It is but fair to state that not a few authorities look on the tissue reaction caused by these non-bacterial irritants as distinct from inflammation, limiting the latter term to conditions resulting from bacterial invasion. The phenomena, however, are identical up to a certain point, and we see no advantage in the suggested dissociation.

The actual **phenomena** of inflammation are perhaps best studied in the web of a frog's foot. If this is spread out and examined under the microscope, the following evidences of normal physiological activity may be seen: (*a*) the flow of blood through the vessels (Fig. 9), as indicated by the movement of the corpuscles—the red ones, each separate from the other, flowing in the central or axial current; the leucocytes occasionally seen amongst the red, or here and there one may be noticed rolling lazily along in the inert corpuscle-free peripheral portion of the tube: (*b*) the constant rhythmical changes in calibre of the arterioles independent of the heart's action, and influencing in a marked degree the flow through the capillaries: and (*c*) the changes which occur in the pigment-cells, and are mainly due to the influence of light, the cells contracting or expanding as the light is increased or diminished.

I. The **Vascular Changes** in acute inflammation. If a crystal of common salt, or some such irritant, is applied to the web, a momentary contraction may perhaps be noticed in the arterioles of the part, but this is only apparent in inflammations produced artificially, and is of no known significance. It is followed by a condition of **Hyperæmia** of the inflamed area, as manifested by a rapid and lasting dilatation of the vessels, accompanied by an increase in the rapidity of the blood-flow (*acceleration*); it is probably brought about by some change in the local vasomotor mechanism present in the smaller arterioles. This increased rapidity of the flow lasts for a while, and then the current gradually becomes slower and slower (*retardation*), as if an ever-growing obstruction existed to the passage of the blood; next a period of *oscillation* will be noticed, the crowded corpuscles swaying forwards and backwards, and finally a condition of *stasis* or still-stand is arrived at, which may or may not end in actual *thrombosis* or intravascular coagulation. During this period the relations normally existing between the vessel walls and the varied constituents of the blood have obviously become modified, as a result of invisible changes in the former, and not of any alteration in the blood. Thus, almost as soon as dilatation occurs, the leucocytes collect along the walls in the peri-axial inert layer, seeming, as it were, to fall out of rank; this process first commences in the veins, but can be observed in all the vessels. The red corpuscles also, which formerly had flowed along separately, now tend to adhere to the vessel walls and to each other, running into rouleaux.

The second factor in the vascular changes, **Exudation,** becomes evident at a very early stage. Every element of the blood participates in this process. It has been already mentioned that the *leucocytes* collect in the peri-axial layer, a phenomenon due partly to an alteration in the vessel wall, whereby it is rendered more 'sticky,' and partly to chemotaxis (p. 18). The next change consists in the passage of the leucocytes through the vessel walls, especially those of the smaller veins and less often of the capillaries. The process is a strictly vital one, brought about by amœboid movement; a small arm or outgrowth of the leucocyte (*pseudopodium*) is inserted between the endothelial cells lining the vessel, whose cohesion has been probably interfered with by the inflammatory process. Into this arm the protoplasm of the leucocyte flows, still further separating the endothelial elements, and thus the cell passes through the wall into the surrounding connective tissues (Fig. 10). The migration of the leucocytes only lasts as long as the blood in the vessel is actually circulating; as soon as thrombosis occurs, migration ceases. When the white corpuscle has escaped into the perivascular tissues, it may undergo various changes. In the first place, it may die and be at once disintegrated, setting free fibrin ferment, and thus assist in the production of the inflammatory coagulum to be shortly described; or, again, it may find its way back into the circulation through the lymphatics, or be transformed into a pus corpuscle; moreover, prior either to disintegration or transformation into a pus corpuscle, it may attack and assist in removing any dead tissue which exists in the neighbourhood of the inflammatory focus, whilst a phagocytic or microbe-destroying function is also subserved. In fact, the leucocytes may be looked on as the scavengers of the body, or as advanced guards, which, at the onset of mischief, are thrown out from the vessels as Nature's first line of defence against the invading forces, their chief duty being to remove all damaged and noxious material, and then, having limited the spread of the destructive process, they in turn give place to larger and more useful

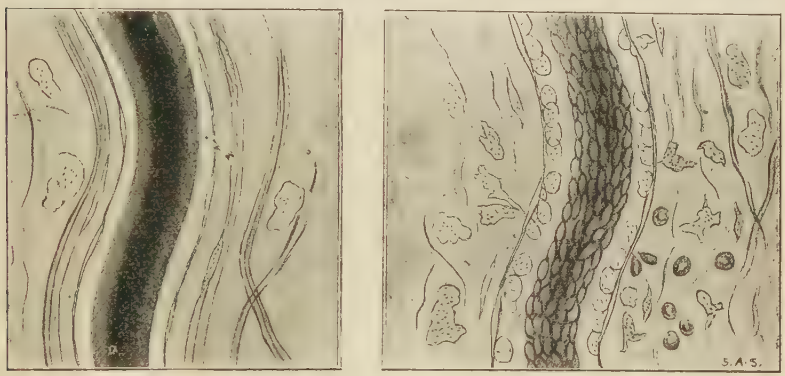

FIG. 9. FIG. 10.

SEMI-DIAGRAMMATIC REPRESENTATION OF THE VASCULAR PHENOMENA OF INFLAMMATION (AFTER THOMA).

On the left is a normal vessel with its peripheral layer free from corpuscles, and its axial stream so rapid that the individual corpuscles cannot be seen. On the right is a similar vessel in a state of inflammation; the blood-current has been retarded so that the individual corpuscles are visible; the leucocytes occupy the periphery of the vessel, and are in process of migration, whilst sundry red corpuscles can also be seen in the surrounding tissues.

cells (fibroblastic) which are the active agents in the process of repair.

The *red corpuscles* pass through the walls of the capillaries by a process of diapedesis, the result of simple mechanical pressure; this usually occurs only in acute attacks. When once external to the vessels, they are broken up and their colouring matter diffused through the tissues, whence, as a rule, it is completely reabsorbed.

The *liquor sanguinis* is also extravasated. This is merely an exaggeration of a normal process, but to such an extent that although for a time the lymphatics of an inflamed region do increased work, yet the transudation is soon greater than they can deal with. If the fluid escapes into the tissues, it undergoes coagulation by meeting the necessary coagulating media developed from the breaking-down leucocytes; *inflammatory lymph* forms locally, whilst the *serum* collects in the meshes of the tissues, constituting an inflammatory form of œdema; if there is a sufficient breach of surface, the serum drains away. If the exudation takes place from a serous surface—*e.g.*, pleura, peritoneum, synovial membrane, etc.—the fluid distends the cavity; it is at first spontaneously coagulable (*i.e.*, consists of plasma); if coagulation occurs, the clot or lymph either forms an adherent plastic mass on the surface or floats free in the fluid.

Looked at, therefore, simply from a vascular point of view,

Inflammation = Hyperæmia + Exudation.

Each of the elements in the inflammatory reaction is of benefit to the patient in combating a colony of bacteria, which together with their toxins have gained access to the tissues. The acceleration of the blood-flow serves in the first place to dilute and to remove the toxin; if the amount present is small, the rapid flow of blood may serve to remove it completely, and then the process begins and terminates in hyperæmia. Further, the increased supply of blood must serve to keep the nutrition of the tissues at its highest level, so that if possible they may be preserved alive in spite of the action of the toxin. Lastly, if the blood contains antitoxins, or other antibodies, or alexins (complements), which inhibit the action of the toxins or destroy the bacteria, these will be brought in large amounts to the region where they are required. The excessive transudation of the plasma may be regarded as an additional means of fulfilling these desiderata. The value of the retardation and stasis of the blood is less obvious, although it probably assists the emigration of the leucocytes, which might otherwise find difficulties in attaching themselves to the walls when floating freely in a rapid blood-stream. The rôle of the leucocytes has been already considered.

II. The **Tissue Changes** in inflammation cannot be so easily observed as the vascular, but are of great importance.

The reaction of the tissues in **acute bacterial** inflammations appears to depend entirely on the irritative power of the toxins, or rather on the relation of this power to the resistance of the patient's tissues. It may be laid down as a general rule that any irritant, if weak enough (*e.g.*, when very diluted), acts as a stimulant to the growth of cells; on the other hand, if sufficiently powerful, it will cause some variety of necrosis or death of the tissues. Uncomplicated examples of tissue-overgrowth in acute inflammation are not often seen in man, since the slighter lesions are rarely examined microscopically. The process is best observed in the early stages of acute inflammation of serous membranes in animals, where the endothelium may be seen several cells thick, whilst its nuclei show active mitosis, proving that cell-proliferation was in progress. An examination of the outer zone of a mass of granulation tissue (where the toxins are present only in small amount) will often show similar appearances.

In most cases, however, the toxins are more active, and death of the tissue results. This is often brought about by what is termed *coagulation-necrosis.* In this condition the tissues and cells become soaked in the coagulable plasma which exudes from the vessels, and the activity of the toxins causes coagulation and death of the whole mass. The result is that all structure disappears from the area involved: the nuclei cease to stain with hæmatoxylin or other basic dyes, and all the tissues stain uniformly with acid stains, such as eosin. The further history of the lesion depends on the nature of the causative organisms. If these are of a pyogenic nature, the necrotic mass will become (or has already become) infiltrated with polynuclear leucocytes, some of which are killed by the toxins, and suppuration follows (see p. 74). When the organism is not of this nature, the polynuclear leucocytes make their appearance in but moderate numbers, and the inflamed area becomes infiltrated with 'small round cells,' which appear to be identical with lymphocytes. It is as yet uncertain whether these are formed locally or whether they are attracted from the blood. It seems, however, tolerably clear that they undergo a local increase by direct division in the inflamed area. If the bacteria are killed and the process stops at this stage, the phenomena of repair supervene (Chapter X.), and the inflamed part is replaced by a mass of fibro-cicatricial or scar tissue.

In **non-bacterial** inflammations of superficial parts the amount of effusion between the individual cells may be so excessive as to separate and disintegrate them, and thus *colliquative-necrosis* may be induced, as occurs in the formation of blisters after a burn.

In **chronic** inflammations, on the other hand, active cell-proliferation is a most important element in the process, resulting in *sclerosis* and induration of the parts. This, however, mainly affects the interstitial tissues, and thereby the true structure of the organ may be impaired.

III. The **Terminations** of inflammation will therefore vary considerably, and more especially with the cause of the trouble, whether bacterial or not, with the intensity and duration of its action, and finally with the powers of resistance possessed by the individual.

In **bacterial** inflammations (1) it is unusual for the tissues so to assert themselves as to permit of the occurrence of **resolution,** or the reappearance of the *status quo ante ;* it is, however, seen occasionally. (2) More frequently **local destruction of tissue** results, and, according to the nature of the bacteria and the tissues involved, this may be followed by (*a*) *repair,* the necrotic tissue disappearing and scar tissue taking its place; (*b*) *suppuration,* in which the affected tissues and the exudate are liquefied and transformed into pus; evacuation of the abscess thereby formed gives exit to the bacteria, the exudate, and the necrotic tissue, and repair is finally brought about by cicatrization ; (*c*) *ulceration,* when the necrotic or suppurative process affects the surface; or (*d*) extensive *necrosis* or gangrene, when the toxic effects of the bacteria are able to break down the tissue resistance to such an extent that the bacteria can diffuse themselves widely through the part. In this connection it is interesting to note that the more highly organized and important organs are always more vulnerable than the simpler forms of connective tissue, and this in spite of the fact that the former are usually better supplied with blood. Thus, the growing end of the diaphysis in a child is a most delicately organized region, and hence is peculiarly liable to serious destructive inflammation from bacterial agents, which would do little harm if developing under similar circumstances in the subcutaneous connective tissues.

When the inflammatory attack is due to mechanical or other **non-bacterial** causes, there is frequently much effusion of fluid, and at first but little cellular exudation, whilst the process is distinctly limited and has no tendency to spread. The most common terminations are: (*a*) *Resolution,* complete and absolute, which is seen not uncommonly; (*b*) the formation of fibro-cicatricial tissue, as seen in the *organization* of lymph into adhesions; (*c*) sometimes the inflammatory process *becomes chronic,* and is then characterized by sclerosis or fibroid thickening of the part, or by persistent effusion into a serous cavity.

Resolution, or the restoration of the part to its natural condition and function, can only occur when the injury has not been so severe as to destroy the vitality of the affected tissues. The phenomena are merely those of inflammation in a retrograde order—viz., an oscillatory movement first manifests itself amongst the corpuscles, and then the blood-stream is gradually restored, slowly at first, and more and more rapidly afterwards. The adhesiveness of the corpuscles disappears by degrees, but it is some time before the peripheral inert layer can be seen. The exuded leucocytes find their way back into the circulation either through the vessel walls, or to a greater extent *viâ* the lymphatics, or else they are disintegrated in the tissues and absorbed. The fluid exudate is removed by the lymphatics. For some time after an acute attack the vessels of the part, especially the veins, are dilated from simple loss of tone, but this also gradually disappears.

Clinical Signs of Inflammation.

The **Local Phenomena** may be described under the four headings suggested by Celsus (about A.D. 50), viz., heat, redness, swelling, and pain, with the addition of a fifth, viz., impairment of function.

Heat.—An inflamed part feels hot to the touch, and the temperature, if taken by a surface thermometer, is definitely raised above that of the surrounding skin. This is due to the increased amount of blood flowing through it, for the temperature of an inflamed area is never higher than that of the blood at the centre of the circulation, *i.e.*, in the heart. The cause of the increased temperature of the blood is noted elsewhere (p. 37).

Redness is due to the hyperæmic condition of the inflamed part. In the early active hyperæmia the colour is a bright rosy-red, fading quickly on pressure, and returning with equal rapidity. During the period of retardation the redness is more dusky, since the blood is longer in passing through the capillaries, and so loses more of its oxygen; the colour does not disappear or return so rapidly, and a slight yellowish tinge often remains from extravasated hæmoglobin. When stasis is reached, and *a fortiori* when thrombosis, pressure does not remove the red colour, and, should such a state persist for long, permanent pigmentation may remain.

When the tissue inflamed is non-vascular—*e.g.*, the cornea or articular cartilage—redness is of course absent until the part becomes permeated by newly-formed vessels. In the case of the cornea, however, a zone of deep pink injection is seen in the ciliary region. A similar absence of redness is observed in an inflamed iris, owing to the excess of pigment hiding the dilated vessels; if, however, the inflammation is very prolonged, the pigment may be absorbed, and the iris becomes obviously red.

Swelling arises from the same two causes, viz., hyperæmia of, and exudation into, the part. Necessarily the amount of tumefaction depends upon the acuteness of the disturbance and the distensibility of the tissue, and in measure varies inversely with the amount of pain. Where the inflamed area is covered by a thick and firm fascia, not only is the tensive pain very considerable, but the chief swelling may occur away from the inflamed area, *e.g.*, over the back of the hand in a palmar abscess; where the inflammatory products escape into lax tissues, the subjective phenomena are diminished, although the swelling may be very great. Similar illustrations of the occurrence of œdema at a distance are to be seen in inflammations of the sole of the foot, and in the swelling of the eyelids when the scalp is inflamed. Swelling due to inflammation, though diminishing after death, does not entirely disappear.

Pain results from the mechanical irritation of the peripheral nerve terminals, both by the increased arterial tension and by the pressure of the exudate, so that it is much greater if, from the density of fascial or fibrous investments, swelling cannot readily occur, *e.g.*, in the palm of the hand, or in the eye or testicle. Possibly the exudate may have some direct chemical action on the nerve terminals, especially when destructive changes are taking place, or if they are insufficiently nourished with healthy blood.

A marked feature of inflammatory pain is that it is always aggravated by pressure, whether intrinsic—*i.e.*, by increasing the blood-pressure, as by hanging down an inflamed hand—or extrinsic, from outside agencies, such as mechanical or digital pressure, the pain then being known as *tenderness*.

The pain of *suppuration* is throbbing in character; of an inflamed *mucous membrane*, scalding, burning, or gritty; of an inflamed *serous membrane*, stabbing; of inflamed *bone*, aching or boring, and often worse at night; of an inflamed *testicle*, sickening. When the organs of *special sense* are inflamed, there may be little real pain, but much exaggeration of the special sense, *e.g.*, flashes of light in retinitis and noises in the ears in otitis interna.

The pain is not limited only to the inflamed part, but is sometimes experienced in distant regions, either through a similarity of nerve-supply or from the fact that a sensory stimulus is always *referred* by a patient to the end of the affected nerve. For example, in *hip disease* the chief pain is often felt in the knee, because both joints derive their nervous supply from similar sources. In *renal calculus* or colic, pain is referred along the course of the genito-crural nerve into the groin and front of the thigh, and is often accompanied in the male by retraction of the testicle on the side affected. In *spinal caries* pain is frequently experienced in the terminal branches of the nerves issuing from the part affected, *e.g.*, the ‘ girdle ’ pain in dorsal disease, and the so-called ‘ belly-ache ’ when the dorsi-lumbar region is affected. Occasionally a sympathetic pain is experienced on the opposite side of the body, especially when a bilateral organ such as the kidney is involved.

Impairment or Loss of Function is due sometimes to the mechanical difficulty of using a swollen organ, sometimes to the pain elicited by such attempts, but often to the paralyzing effect of the inflammatory process, and this in infective lesions results from the direct influence of the toxins on the protoplasm of the cells affected. Thus, an inflamed eye is from various causes of little use for vision; a muscle, when inflamed, is naturally kept at rest; glandular organs, *e.g.*, the liver and kidneys, have their functions, if not lost, at least much diminished; and many similar illustrations might be added.

Constitutional Symptoms are constantly present in inflammatory conditions, and vary greatly in their severity with the cause. In non-bacterial cases there is usually some slight fever which does not last long; but when bacteria are present, the absorption of toxins may cause general symptoms varying in degree from a mild febrile reaction to a grave toxæmia which causes death. It is, however, astonishing to note how much disturbance a small bead of pus under tension may sometimes produce.

It is only necessary at this place to deal very briefly with the subject of **Fever** or pyrexia. The general characteristics of the febrile state consist in a greater or less elevation of temperature, accompanied by a corresponding acceleration of the rate of the heart-beat and of the respirations. If it continues, the patient becomes thin and emaciated, and loses muscular power. The mouth is dry and the tongue furred; and in the later stages the lips and teeth are usually covered with sordes (or accumulations consisting of inspissated mucus and food débris). The appetite is impaired, digestion is imperfect, and the bowels constipated; the motions are often very offensive. The urine is scanty and high-coloured, and owing to the excessive tissue change contains an unusual amount of urea and urates. The excess of urea is demonstrated clinically by adding an equal part of cold nitric acid in a test-tube to some urine, when crystals of nitrate of urea will form on the top of the fluid, giving rise to a mass somewhat resembling sugar-candy in appearance. The skin of a febrile patient is often dry.

Causes of Fever.—The temperature of the body, it is well known, is controlled by a principal heat-governing centre in the corpus striatum, assisted possibly by accessory centres in the cord, and is maintained by the establishment of equilibrium between the amount of heat lost from the skin, by the breath, and in other directions, and the amount of heat produced by the tissue metabolism occurring in the viscera generally, and especially in the voluntary muscles. Pyrexia is necessarily due to one of two causes, viz., a decreased loss of heat, or an increased production. The former is a scarcely tenable proposition when we look at the patient's condition, and hence we are driven to conclude that fever is due to increased activity in the heat-forming tissues, especially the muscles, a fact which explains the rapid emaciation and loss of strength under such circumstances, and the presence of a large amount of extractives in the urine. In all probability this increased activity is due to the excitation of the heat-producing centres by some pyrogenous body developed in connection with the local inflammatory process. Experiments have shown that fibrin ferment, various products of the breaking down of tissues, and many of the toxins produced by the action of micro-organisms possess such a power.

In regard to the symptoms of fever, it may be stated briefly that they are in large part due to the effect produced by the increased temperature or the toxic products circulating in the blood upon the constituent cells of glandular and other organs. The phenomena in question are termed by different pathologists 'acute or cloudy swelling,' 'granular degeneration,' 'albuminous infiltration,' etc., and are characterized by the organs becoming soft, friable, and more or less swollen. The secreting cells of glands are increased in size, and the protoplasm becomes markedly granular, so that the nucleus can only be distinguished with difficulty. The granules are albuminous in character, clearing up completely on the addition of acetic acid. A similar change is also evident in the fibres of the cardiac muscle, which lose their striation and become granular, a condition which must considerably interfere with their contractility. The effect produced upon the glands of the digestive system explains many of the febrile manifestations. The salivary and buccal glands are unable to excrete the normal amount of saliva, and hence the mouth becomes dry, whilst gastric digestion is interfered with in a similar way.

The intensity and character of the fever vary with the preceding condition of the patient, and also with the nature and duration of the disease. In young healthy adults of sound constitution, the fever associated with an acute inflammation is usually of an active type, pyrexia and its accompanying phenomena, including a noisy delirium, being well marked (*sthenic* inflammatory fever). In debilitated subjects, as also towards the close of a long period of pyrexia (*e.g.*, in the third week of enteric fever), and in grave infections such as erysipelas and septicæmia, exhaustion and collapse manifest themselves (*asthenic* fever, or the typhoid state). The pyrexia is not necessarily high, and the patient often passes into a condition of low muttering delirium, picking at the bedclothes, passing his excreta into the bed, and more or less unconscious.

Varieties of Inflammation.—Many different terms are used to indicate the manifestations of the inflammatory process in the body, and to some of these we must now direct attention.

A **Catarrhal** inflammation is one affecting mucous membranes, which in the early stages become dry, vividly red, and the seat of a burning or scalding pain, whilst in the later stages there is free secretion of mucus, muco-pus, or pus. At first the mucigenous function of the hyperæmic membrane is abrogated, and any extravascular exudation passes into its substance, causing it to become swollen. Proliferation of the epithelium soon follows, resulting in an increased formation of mucus; as the membrane becomes more and more infiltrated with leucocytes, these are added to the discharge, which is thus transformed into muco-pus, or even pus. Small ulcers may develop from the loss of superficial epithelium, but this is an exception rather than the rule. Microscopic examination of the discharge reveals pus cells, leucocytes, and epithelial elements in various conditions, some containing globules of mucin, and some of the normal type. This form of inflammation is caused by bacteria, or by the action of local irritants, or by what is known as 'taking cold.'

A **Croupous** or **plastic** inflammation is one characterized by the formation of a firm false-membrane, due to the coagulation of the plasma exuded from the vessels, the resulting fibrin being deposited on the surface. When involving a serous surface, such as the pleura, peritoneum, or synovial membrane, it gives rise to a layer of plastic lymph, which may organize into adhesions; it is also seen in the alveoli of the lungs in lobar pneumonia. On mucous membranes, such as the conjunctiva or that of the pharynx, it occasionally forms white, flaky masses, which can be readily detached, leaving an injected surface below, with merely one or more oozing points, and no loss of substance.

A **Diphtheritic** inflammation is, properly speaking, one that is due to the action of the diphtheria bacillus on a free surface (p. 133). The term is, however, often applied to inflammatory processes due to other causes, but resulting in a 'false-membrane' of similar nature. This differs from the false-membrane of croupous inflammation in that it is formed, in part at least, by necrosed *tissues*, and not simply by fibrin deposited on the surface. Hence it is more difficult to 'peel off,' and when this is done a raw bleeding surface is left.

The term **Phlegmonous** is now but rarely employed. It was formerly applied to any inflammation of the subcutaneous connective tissues where the local phenomena tend to spread, and there is a well-marked brawny inflammatory swelling or phlegmon.

Parenchymatous and **Interstitial** are terms which indicate that in an inflamed organ or gland the process is mainly limited, either to the actual and active substance of the organ, or to the supporting fibrous tissue.

The term **Metastasis** was formerly employed to indicate a sudden transference of an inflammatory attack from one place to another without apparent cause. Increased knowledge of pathology has explained away nearly all the formerly-described illustrations of metastasis, and, indeed, the use of this term is now almost limited to the inflammation of testis, ovary, or breast which follows mumps. It is often incorrectly applied to the secondary abscesses of pyæmia and to the secondary deposits of malignant disease, both of which are of embolic origin.

Treatment of Acute Inflammation.

It is only possible here to deal with the general principles which guide us in the treatment of inflammatory affections; the application of these to different parts of the body will be considered later.

I. **The Local Treatment of Non-bacterial Inflammation.**—1. *Remove the exciting cause,* if evident, and any contributory causes when feasible. This is not a difficult matter when the lesion is a gross one and the exciting cause tangible, *e.g.*, a foreign body imbedded in the conjunctiva or cornea, or the use of a chemical irritant such as formalin in an occupation eczema. In the majority of cases, however, the exciting cause has ceased to act, as in the case of blows, sprains, burns, etc., and all one can do is to protect the part from further irritation or bacterial infection, to relieve tension, and then to assist the tissues towards healthy repair.

2. *Keep the inflamed part at rest.* Wherever inflammation exists, both physical and physiological rest should be secured as far as possible. Thus, an inflamed joint is immobilized; an inflamed mamma needs both support and the fixation of the arm, whilst if in a condition of physiological activity this must be checked; an inflamed cornea needs the application of a pad and bandage to prevent the friction of the eyelid; an inflamed retina is put to rest by exclusion of the light.

3. *Reduce the local blood-pressure* and hyperæmia, and thereby relieve tension by diminishing both exudation and pain. It may be pointed out here that, although both hyperæmia and exudation are beneficial, yet they are almost always present in excess, and it becomes needful to keep them under control. *Elevation* of an inflamed limb may secure this end, and is usually required in inflammatory conditions of the leg, for it is well known that emptying the veins by gravity leads to reflex contraction of the arteries. This principle must not be carried to excess, or serious interference with the vitality of the limb may result. The rule adopted is to raise the affected part to such an extent as to assist the venous return without interfering with the arterial supply. *Local blood-letting* by punctures, scarification, and wet or dry cupping, is

useful in suitable cases, and sometimes gives immediate relief to pain.

Cold wisely utilized is of the greatest service in reducing hyperæmia by causing contraction of the arterioles. It should only be used *in the early stages,* as it depresses the vitality of the part, and so, if much congestion is present, may do more harm than good. Again, it should be used with the greatest care in old people, from fear of causing necrosis of the skin. There are various methods of applying it, as by means of an ice-bag; or by irrigation from a vessel suspended over the part, containing iced water or lotion, from which strips of lint descend to envelop the inflamed area; or a piece of lint wrung out of evaporating lotion may be placed directly on the part; or, better still, the iced water may be run through a coil of leaden pipes (known as Leiter's tubes), fitted carefully to the inflamed region.

Heat, especially when combined with moisture, is very largely used in treating inflammatory affections, and acts in a diametrically opposite way to cold by relaxing the vessels and tissues, thus reducing the tension and pain; it also favours the activity and vitality of the part by increasing the vascular supply and facilitating lymphatic absorption. For subcutaneous lesions, rubber hot-water bottles, fomentations, medicated or not with opium or belladonna, or spongiopiline wrung out of hot water, poultices, or simply dry heated cotton-wool, may be employed. Other methods of employing dry heat are suggested in Chapter III., but are more applicable to the chronic varieties of inflammation.

II. **The Local Treatment of Inflammation of Bacterial Origin.**—This is a somewhat different problem in that its object is to destroy bacteria, to eliminate their toxins, and to attain this end with as little destruction of tissue as possible. The chief difficulty lies in the stagnation present in the bloodvessels and lymphatics of the inflamed part, so that no fresh blood is circulating through it. At the same time the toxins formed by the bacteria have the opportunity of acting on the tissues, and are absorbed into the blood, thereby leading to its deterioration. The means at our disposal of combating a bacterial inflammation are: (*a*) The antitoxic and bactericidal properties of the blood, which can be influenced beneficially by antisera, vaccines, drugs, and diet; and (*b*) external applications and procedures, directed towards the removal of stagnant blood and exudate, and to the provision of a sufficient supply of fresh blood which shall assist the tissues in the direction of repair. The actual methods are as follows:

1. Remove the cause if possible, as, for instance, an infected foreign body, or a buried stitch at the bottom of a sinus. In a few cases it may be possible totally to excise a local focus—*e.g.*, a malignant pustule; whilst in others, such as a carbuncle, one can scrape away the infiltrated and sloughy tissue with a sharp spoon.

2. Keep the inflamed part at *rest* as far as possible, not only for physical and physiological reasons, but also to prevent mechanical

dissemination of the infective virus. This may be effected by confining the patient to bed, or by the use of splints or slings.

3. Unload the stagnant vessels, both veins and lymphatics, by elevation, hot applications, which soften and relax the tissues, or local blood-letting. Scarification is of great value in the slighter cases; but when stasis has occurred, free incisions are often indicated in order to relieve tension, and also to allow of the escape of bacteria and their toxins.

4. Promote the removal of the exudate by the insertion of rubber drainage-tubes into deep inflamed cavities, such as abscesses or sinuses, or by packing an open wound with gauze and covering it with a fomentation or a hydrophile dressing, encouraging thereby capillary drainage. In other cases immersion of the inflamed area in a bath at a temperature of 99° to 105° F., either of sterilized salt solution, or of some mild antiseptic, such as boric acid, may be of great value in diluting and washing away toxins and cleansing the part; but it must not be used to excess, or repair may be hindered by the tissues becoming waterlogged.

5. Increase the supply of healthy blood to the part by the application of heat, as by poultices when the skin is unbroken, or boric acid fomentations if there is a wound, or by employing one of the methods of artificial hyperæmia suggested by Professor Bier.

Artificial or induced hyperæmia as a means of treatment for inflammation is based on the assumption that the hyperæmia and accompanying leucocytosis present in all its forms are useful rather than harmful if they can be suitably controlled; but in acute cases the hyperæmia is usually excessive, and therefore harmful by preventing the access of fresh healthy blood to the part. Bier's treatment requires the relief of this natural harmful congestion by elevation, etc., and subsequently replaces it by a controlled hyperæmia, the parts being flooded from time to time with fresh blood, which can by its contained antibodies assist in destroying bacteria and bringing about a cure.

Induced hyperæmia is of two types, active and passive. The *active* variety consists in determining an increased flow of blood to the part by vaso-dilation, and is arterial in origin. It is best accomplished by heat, either by fomentations, or immersion in hot water, or by one of the diverse methods of applying hot air now available. This plan is not so generally beneficial in acute cases as passive hyperæmia, but may be useful in the later stages by hastening the absorption of inflammatory exudates, thereby completing the cure.

Passive hyperæmia is venous in origin, and may be induced by the application of a constricting bandage on the proximal side of the inflamed area, or by the use of Klapp's suction balls. The *constricting bandage* is of elastic material, and Martin's rubber bandage may be suitably utilized. It is applied with sufficient firmness to obstruct the venous return without interfering with the arterial supply, and if this is satisfactorily effected, the limb becomes reddish-blue, swollen, and œdematous, but without pain; if it becomes cold, or the patient complains of the pain being increased, the bandage has been applied too tightly. When the correct degree of tension has been reached, the limb is comfortable, and the bandage may be retained in position for twenty or more hours at a stretch, being removed each day for two or three hours in order to relieve the œdema and empty the limb of the accumulated and more or less stagnant blood. This method of treatment is maintained until the inflammation diminishes, and then the length of the daily application of the bandage is gradually reduced.

Klapp's suction balls (Fig. 11) are employed in cases where a rubber bandage cannot be applied—*e.g.*, for an abscess or carbuncle on the trunk or back of the neck, for an inflamed breast, or for a septic finger. A suitably-shaped bell-glass (similar in type to the wet or dry cup of olden days), the edge of which is greased or moistened, is fitted over the inflamed part, and the air within rarefied by a rubber suction-pump. Blood is thereby drawn into the tissues, which swell up into the cup; and if there is an open wound, as in a boil or carbuncle, discharge and sloughs are sucked out therefrom. The application is maintained for five or ten minutes two or three times a day.

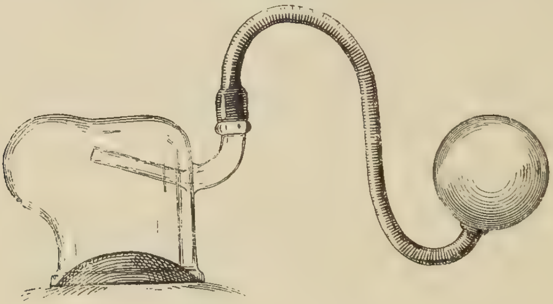

FIG. 11.—KLAPP'S SUCTION BALL.
Suitable for small superficial infections, *e.g.*, boils or carbuncles.

6. Prevent the access of fresh or a mixed infection to an open wound by suitable dressings and antiseptics.

III. **General Treatment of Inflammation.**—This varies considerably with the condition of the patient and the severity of the attack.

In robust patients where the blood-pressure is high, the pulse large and full, and the local signs, pain, etc., well marked, it may be advisable to lower the arterial tension by means of such drugs as antimony, aconite, ipecacuanha, acetate of ammonia, colchicum, etc., whilst means are also taken to determine free activity of the skin, kidney, and bowels, whereby toxins and other irritating substances may be eliminated from the body, and the blood thereby purified. In a few cases—viz., acute pneumonia or meningitis—it may even be desirable to resort in the early stages to venesection, but only in powerful, full-blooded adults, and never to such an extent as unduly to lower their resistance. Subsequently the administration of a suitable supply of simple, easily-digested food is required, the exact nature of which depends on the temperature and the condition of the digestive organs, as indicated by the tongue.

When the patient is weakly and feeble, and especially when his strength has been gradually sapped by persistent fever and toxæmia, general treatment is mainly a matter of feeding, and depends as much on the care and devotion of the nurse as on the skill of the doctor. Stimulants may be required in these cases, and, of course, the functions of the bowels and kidneys must be suitably attended to, though without depressing the patient's strength.

It is probable that moderate pyrexia is useful rather than harmful in infective diseases, in that it encourages the formation of antibodies. Hyperpyrexia, however, is harmful, in that it paralyzes the tissues and checks the production of these substances. It is unnecessary, therefore, to employ antipyretic measures except when the temperature runs high, and the chief reliance should then be placed on drugs such as quinine or aspirin, or on tepid sponging.

Chronic Inflammation.

The **Causes** are similar in character to those producing the acute mischief, but slighter and more prolonged in their action. The most striking point in the ætiology is the large part played by diathetic conditions or constitutional predispositions. Most of the manifestations met with in surgical practice are due to syphilis, tubercle, gout, or rheumatism, and one should never treat chronic cases without carefully inquiring as to the possible existence of some such taint.

The **Phenomena** are essentially the same as those of the acute process, though the manifestations are somewhat different.

1. The *hyperæmia* is less in degree, but longer in duration, owing to the causative irritant being frequently of little activity. The local manifestations, therefore, are less obvious; pain is not so great and mainly of an aching character, whilst there is less heat, the redness is more dusky, and the tissues often become pigmented. Considerable loss of tone in the vessels, especially the veins, results from their prolonged distension, and thus there is greater difficulty in restoring them to a normal state.

2. The corpuscles do not adhere together or run into rouleaux to the same extent as in acute inflammation, and migration, though it exists, is on a limited scale. The *exudation* is more fluid in character, containing comparatively little albumen or fibrin; in fact, in some chronic inflammations of serous membranes the cavities are distended with fluid of a much lower specific gravity than that of blood serum.

3. The greatest difference between the acute and chronic processes lies in the *reaction of the tissues*. In acute inflammation, increased proliferation of the tissues is rarely a marked feature, since

the toxin has usually sufficient power to destroy their vitality. In chronic inflammations this is not the case, at least not until the later stages of lesions like those of tuberculosis or syphilis.

An area which in is a state of chronic inflammation is infiltrated with round cells which are derived from various sources. (*a*) In certain tissues cell-proliferation is well marked, especially in the endothelial cells of the vessels and lymph-clefts, or the secreting cells of the breast, whilst in other parts (*e.g.*, the central nervous system) the cells never undergo proliferation. (*b*) In most cases, however, these round cells are *lymphocytes*, and are often found grouped in large numbers round the smaller vessels; in the chronic granulomata this is very characteristic, large areas composed entirely of lymphocytes being met with. (*c*) Another cell which is often found in these lesions, and has recently attracted much attention, is the *plasma-cell*. It is much larger than a lymphocyte, and usually of an oval shape; the nucleus is about as large as that of a lymphocyte, is usually divided into five or six segments, and is placed excentrically in the cell. The protoplasm has peculiar staining affinities. These cells sometimes occur in chronic inflammatory lesions in great numbers, scarcely another type being seen in areas of considerable size; but usually they are mixed with lymphocytes.

From whatever source they are derived, these newly-formed cells usually develop into fibrous tissue, but sometimes produce structures more or less resembling normal tissue. Organization is therefore a marked feature of chronic inflammation. The actual **Results** vary according to the part of the body affected, and also with the predisposing diathetic state. In *simple* chronic inflammation, not due to tubercle or syphilis, the part becomes infiltrated and enlarged, and if this persists, fibrosis or sclerosis follows. Thus, a bone is thickened and condensed in chronic osteitis (*osteo-sclerosis*), whilst in chronic periostitis a new subperiosteal formation of bone occurs. Glands become enlarged and indurated, mainly by hyperplasia of the connective tissue, whilst if the skin is involved it either becomes hypertrophied and thickened, or entirely loses its characteristic structure, being converted into granulation or fibro-cicatricial tissue, with or without an intervening ulcerative stage. True suppuration rarely occurs, although certain organisms of low virulence occasionally lead to its development.

Constitutional symptoms are but little evident, beyond those dependent on the diathetic condition to which the local phenomena are due, or to septic changes developed secondarily.

The **Treatment** of chronic inflammation is usually more prolonged and difficult than that of acute cases, because of the constitutional dyscrasia which exists so frequently behind it.

1. The *cause must be removed* whenever practicable. Dead or diseased bone must be removed, and tuberculous material got rid of by the knife or sharp spoon, whilst it is often desirable to supplement this by swabbing the parts over with liquefied carbolic acid.

A chronic abscess increases the action of the original irritant through the tension engendered by its presence, and hence it should be dealt with as early as possible.

2. *Keep the part at rest.* This is just as much an essential as in the treatment of acute inflammation. Joints should be immobilized; the spine must have the weight taken from it by suitable appliances, or, better still, by maintaining the recumbent position; secretory glands are not actively exercised, and the organs of sense are protected from irritation.

3. *Counter-irritation* is one of the most useful forms of treatment for chronic inflammatory conditions. It is applied in many different ways, according to the character of the disease and the part involved. Thus, *friction* with the hand, or with stimulating embrocations, produces a hyperæmic condition of the skin, and promotes local activity in the superficial parts which may react beneficially on deeper structures. *Scott's dressing* may be similarly employed; it consists in wrapping up the part (*e.g.*, a joint) in strips of lint covered with ung. hydrarg. co. (containing over 10 per cent. of camphor), and then encircling it firmly with soap plaster, spread preferably on chamois leather. *Iodine paint* is another useful application, whilst *blisters* are most valuable in suitable cases; they are produced by applying a cantharides plaster, or by painting the affected area with liquor epispasticus or a collodion blistering fluid. The *moxa*, a wound produced by burning a spirituous solution of saltpetre on the skin; the *issue*, the maintenance of a raw surface, however produced, by the constant presence of some irritant, such as the insertion of a bead, or the use of savin ointment as a dressing; and the *seton*, a double thread knotted at each end, passed for some distance under the skin, and drawn from end to end daily—all these are but little used now, although they might be occasionally employed with advantage. The *actual cautery* is the most severe form of counter-irritant, and is especially useful in some varieties of chronic inflammation of bones and joints. The exact *modus operandi* of counter-irritation is a little difficult to understand, but it seems likely that in some cases they act by determining hyperæmia of the part, and in others through some influence on the nervous supply.

4. *Pressure* is an important element in the treatment of chronic inflammatory disorders, and probably acts by bracing up vessels which have become relaxed and atonic from the prolonged distension to which they have been subjected. It also favours the absorption of inflammatory exudations. Firm bandaging, and especially the use of an elastic support, are the usual methods of application.

5. *Artificial hyperæmia* (Bier's treatment) is also of value in chronic inflammation, and perhaps finds most useful expression in the form of hot-air baths, or various electrical methods noted elsewhere (Chapter III.), or in the direction of massage and remedial exercises.

Massage is also a valuable means of treatment of many chronic inflammatory affections and other lesions. In its simplest variety it consists in rubbing with some embrocation or liniment, and the stimulating effect of the latter may be of some value in determining hyperæmia of the part. In its more elaborate forms it constitutes an art which is of the greatest value, and concerning which lengthy text-books have been written. It must suffice here to point out that the chief varieties of movement are known as effleurage, pétrissage, and tapotement. *Effleurage* consists in plain up and down rubbing of the limb with the flat of the hand, the up stroke being always firmer than the down, so as to assist in the return of the blood and lymph from the part. In this way the circulation is quickened, and the vital activities of the tissues are increased. The skin should be lubricated with oil, vaseline, or some stimulating embrocation, and the rubbing, at first light, so as only to affect the skin and subcutaneous tissues, should gradually become firmer, so as to influence the deep structures. *Pétrissage* consists in kneading the muscles or other tissues between the finger-tips and the palm of the hand; this necessarily should be done across the muscle fibres, working from below upwards, and is especially valuable in hastening the absorption of exudations. In *Tapotement* a series of blows perpendicular to the surface is rapidly delivered by the ulnar side of the open or clenched hand; the circulation in the parts thus struck is much quickened, and when skilfully done no pain should be caused.

As a modification of the last proceeding, *Vibro-massage* has been recently introduced, in which rapidly repeated blows of the affected region give rise to a vibratory effect, which is often of the greatest value. Hand vibrateurs are sold, and may be used with advantage; but the best results follow from the employment of vibrateurs worked by electricity. Rheumatic inflammation of joints and fasciæ, such as occurs in lumbago, some forms of sciatica, and other neuralgic conditions, are often much benefited by this procedure.

6. *General* or constitutional treatment must be adopted to meet the specific diatheses which are commonly associated with chronic inflammation, *e.g.*, mercury or iodide of potash in syphilis.

7. Finally, if the condition is bacterial in origin, and the organism can be isolated, a *vaccine* may be prepared and treatment carried out on the lines laid down on p. 26. Ordinary surgical methods should, however, not be neglected.

CHAPTER III.

THE USE OF HEAT, LIGHT, ELECTRICITY, AND RADIUM, IN SURGERY.

WITHIN recent years there has been so large a development in the application of various physical agencies in the realm of medicine that it seems desirable to discuss their powers and applications in one chapter, and we propose in this to discuss the use of heat, light, electricity, and radio-activity.

Heat (Thermo-Therapy).

Apart from its value as a sterilizing agent, heat is of use in treatment on account of the active arterial hyperæmia it produces, whereby the part to which it is applied is bathed with fresh blood containing defensive agents, such as leucocytes, opsonins, antitoxins, and other antibodies, by means of which the activities of harmful bacteria and their toxins are neutralized. Moreover, when applied to a part which is infiltrated and brawny, it assists in the restoration of a healthy circulation, as already mentioned (p. 40), by softening and relaxing the tissues.

Heat is employed in two chief forms—viz., as moist or dry heat—and either may be utilized as a general or a local application.

1. **Moist Heat** is utilized *locally* in the form of the fomentation or poultice (p. 40), in order to assist an inflamed part to healthy repair. It matters little as to the material employed when the skin is unbroken, so long as it retains the heat, and, with this object in view, a linseed poultice is often preferable to a fomentation. When, however, there is an open wound, the fomentation or poultice must be aseptic at least, if not antiseptic, in character. The *boracic fomentation* is useful in these cases, consisting of boracic acid lint wrung out of boiling water, or a *carbolized poultice* may be employed. This latter consists of linseed-meal mixed with boiling lotion (1 in 40), and applied, not directly to the wound, but over a few layers of cyanide gauze. A hint is given elsewhere (p. 84) as to the dangers of using carbolic acid in chronic infective cases with amyloid changes in the kidneys. Occasionally it is desirable to add a counter-irritating effect

to the poultice, so as to influence underlying inflammatory conditions—*e.g.*, bronchitis, etc.—and then a suitable proportion of mustard may be added to the linseed.

Generally, moist heat is employed in the form of a *hot bath*, and, apart from its cleansing purposes, this is most valuable in many conditions and for varying purposes—*e.g.*, to act as a sedative in cases of slight shock and general bruising of the body after accidents; to assist in the painless removal of extensive dressings which might stick to raw surfaces, such as burns, especially in children; to dilute toxins and help in their removal from the body, as in extensive infected wounds. The hot bath is also used in various schemes of hydro-therapy in order to act upon many foci of chronic inflammatory trouble; *e.g.*, in general muscular rheumatism and fibrositis, the heat of the bath helps to relax and loosen the parts, and thereby to restore them to a healthy function. Plain water may be utilized for this purpose, or hot mud or peat baths. Active chemical substances, such as alkaline carbonates, sulphur, etc., naturally present in the water, or artificially added to it, are readily absorbed through the skin, and influence the patient considerably; natural mineral waters are probably more active than those artificially prepared.

2. **Dry Heat** may also be made to serve as a therapeutic agent, generally or locally, but in most instances introduces a new element—viz., diaphoresis as well as superficial hyperæmia. It is especially valuable in chronic cases, and, of course, higher temperatures can be borne without discomfort than in the preceding variety.

Generally, various methods of hot air or vapour baths are available. *Turkish baths* consist in the exposure of the unclothed body to dry heat at varying temperatures (up to 250° F. or more) for twenty or thirty minutes; by this means an abundant perspiration is induced, and thereby toxins are eliminated. It is followed by massage, douching, and rest for an hour or so, to allow the surface of the body to cool. A *Russian bath* is very similar, but the air is full of the vapour of steam, and therefore cannot range so high; perspiration is induced more rapidly, and the bath is of shorter duration. In both of these agents the object is to induce the rapid elimination of toxins and other poisons, and at the same time to assist in maintaining the free mobility and function of the various parts of the body by massage. Either may be employed advantageously as a routine preventive of gout or rheumatism, especially by those who are unable to secure suitable exercise; or they may be utilized as a means of cure.

In patients who are incapable of leaving their beds or homes—*e.g.*, in cases of uræmia, or of very bad chronic rheumatism—hot-air baths may be given by covering the patient with a large cradle over which is placed a blanket or two, and under it, in such a way as not to endanger him, a lighted spirit-lamp or a suitable number of electric lights of sufficient power. Occasionally, however, wet packs have to be relied on in such cases.

Locally, there are many methods of applying dry heat to a part, of which the following are the chief:

1. *Hot-air baths*, such as the Sheffield-Tallerman apparatus, etc., consist essentially of a box or chamber with walls composed of felt or asbestos, and arranged so that the contained air can be heated to a required temperature by an oil or gas burner. The affected limb is introduced into the chamber through a window with a closely-fitting curtain, and carefully suspended to prevent the skin touching the hot walls, thereby avoiding burns. Recently air baths heated by electric currents passing through metallic resistances have also been used.

2. *Radiant-heat baths* have electric incandescent lamps as their heating agents. The therapeutic value of these baths depends not only on the hot air evolved, but also, and probably mainly, on certain light rays which have no heating power. A bath consists of a cabinet containing a number of lamps, which may have various-coloured globes, so that, by absorbing rays corresponding to certain portions of the spectrum, the quality of the light may be varied. They may be used for the whole body or for individual limbs.

3. *Diathermy*, or thermo-penetration, is somewhat akin to the high-frequency current, but has a sustained instead of an interrupted oscillation. A current of high potential is passed through the affected part, which offers some resistance to its passage, and thereby its temperature is raised several degrees. The action of this agent, therefore, differs from hot-air baths, etc., in that the *internal* temperature of the body is raised rather than that of the external air, and hence the therapeutic results are increased.

Applications.—Hot-air and radiant-heat baths are chiefly employed to promote the absorption of chronic inflammatory exudates, and for such conditions as chronic arthritis, adhesions, neuralgia, lumbago, and sciatica. They are also used to aid elimination by determining diaphoresis in general toxic conditions, such as gout, Bright's disease, and obesity. Diathermy is useful for chronic inflammation, osteo-arthritis, rheumatic and gouty fibrositis, etc.

Heat is also of great value in preventing or counteracting shock. The importance of keeping a patient warm during a lengthy operation is emphasized again and again, and to this end operating-rooms are now maintained at a high temperature (70° to 80° F.), and the patient is carefully clothed. This is a much better method to employ than to heat the table on which he lies, a procedure which has before now resulted in serious burns to the back or buttocks. To combat the shock which follows operations or serious injuries, such as bad burns, especially in children, when the patient's temperature often falls as low as 95° or 96° F., it is important to surround the body with air at a higher temperature; and this can be effected by covering him with a cradle over which a blanket is placed, merely leaving the head uncovered, and within which is placed an electric lamp of 50 or 100 candle-power, so that it cannot touch or be touched by the patient's limbs. The result of this hot-air bath is often most valuable.

Cauteries are employed in three forms:

1. *The actual cautery*, which consists of solid irons of various shapes, and these are heated in a suitable flame to a temperature depending on the use for which they are required.

2. *The galvano-cautery* consists in a loop of platinum wire mounted on an insulated handle, and connected with the terminals of a battery of sufficient strength. The handle is fitted with a key, so that the current may be opened or closed at will. During the passage of a sufficiently strong current (5 to 6 ampères for small loops) the platinum becomes red or white hot.

3. *Paquelin's thermo-cautery* depends on the principle that, when the vapour of benzoline is driven over heated platinum, its combustion generates sufficient heat to maintain or increase the temperature of the platinum. By means of a rubber bellows, air is driven over the surface of benzoline contained in a bottle, and then, saturated with its vapour, through a hollow handle into a platinum point. The platinum point is previously heated to a dull redness in a spirit flame, and on pumping the mixture through the apparatus it can be kept at a red or white heat.

Applications.—1. *As a counter-irritant*, when the skin over an affected part, usually a joint or the spine, is seared lightly.

2. *As a hæmostatic* or bloodless knife. By this means vascular tissues can be divided without loss of blood, and at the same time the tissues involved are kept or rendered aseptic. Thus, polypi or piles can be removed in a bloodless fashion, and the stump is left sterile. It is also employed to divide the intestine between clamps without soiling the peritoneum. It is well to remember that a dull red heat is the most efficacious, since thereby the vessels are seared and effectively closed; a cautery at white heat cuts almost as cleanly as a knife. The possibility of secondary hæmorrhage when the slough separates must not, however, be forgotten.

Light.

Light as a curative agent, apart from its thermal effects, is chiefly employed in the form of (1) the arc light, (2) Finsen and mercury vapour lamps, and (3) sun-baths.

1. The projection of the light from an *arc lamp* by means of a suitable concave mirror may be employed as a general bath, or locally to diseased areas. The heat evolved by the lamp can be projected to some depth beneath the surface, and care must be taken not to burn the patient by focussing the rays on the skin. This method differs from radiant heat in that its light contains abundantly the chemical rays of the violet end of the spectrum, whilst that of incandescent lamps contains mainly the heat rays of the red end. This method is utilized for conditions similar to those for which radiant heat is employed, but more especially in

cases where a localized application is required—*e.g.*, in lumbago, rheumatic torticollis, etc.

2. The Finsen and mercury vapour lamps are methods of exposing small areas of disease to large doses of light containing an abundance of chemically active rays. A *Finsen* lamp consists of a powerful arc, the rays of which are collected and focussed by quartz lenses on a small area of skin, which is cooled and rendered anæmic by a quartz compressor, through which a stream of cold water flows. Compression aids the penetration of the rays by rendering the part bloodless, the blood having the power of absorbing the violet rays. The *mercury vapour* (Cooper Hewitt) lamp consists of a glass tube exhausted of air, and containing mercury and mercury vapour. The passage of a suitable current through this produces a light rich in ultra-violet rays. These lamps are chiefly used in the treatment of lupus, although better results are often obtained by the X rays.

3. *Sun-baths* need no special comment, but there is no question as to their value in cases of anæmia and malnutrition, especially since they involve exposure of the body to an abundance of fresh air.

Electricity.

Electricity, apart from its thermogenic power, has many important applications in the domains both of diagnosis and treatment.

1. **As a Diagnostic Agent.**

(1) By means of the *faradic and galvanic currents* the electrical response of muscles and nerves can be investigated, and valuable information obtained as to the condition of the nervous and muscular systems.

A muscle with a normal nerve-supply contracts under stimulation from both the faradic and galvanic currents in sufficient strength, the contraction being most readily obtained when the electrode is applied over a definite skin area, varying for every muscle, and called the ‘ motor point.’ With the galvanic current the contraction obtained, when the current is closed, is greater than that produced when the current is opened. Again, the contraction elicited when the electrode applied to the muscle is attached to the kathode of the battery is greater than that resulting when the anodal electrode is used. This fact is expressed in the formula —K.C.C. > A.C.C.

In the muscular degeneration which follows nerve injuries, neuritis, anterior polio-myelitis, etc., these reactions are modified, and constitute the *reaction of degeneration* (R.D.). The response of the muscle and nerve to the faradic current quickly disappears, and with the galvanic current the anodal closure contraction becomes greater than the kathodal (A.C.C. > K.C.C.). A greater strength of current will be required than in the sound side of the body, and the response will be sluggish, and not brisk. As long as the R.D. persists, however, the possibility of repair in the muscle remains, should the centres and conducting apparatus be restored. This persistence of the R.D. may exist for years. When once the R.D. is lost, all hope of repair is gone. In spastic conditions the electrical irritability of muscles and nerves is often increased.

(2) *Radiography.*—When a current from the secondary circuit of an induction coil is passed between two suitable metal electrodes in a vacuum tube of a high degree of exhaustion (Crookes tube), a stream of rays, called 'kathodal' or 'β rays,' which consist of negatively charged electrons, is generated from the kathode. If the kathode is concave, and the rays are thereby made to converge to a focus on a third electrode called the 'target,' or 'antikathode,' from their impact thereon results a production of rays of a very special character, known as the 'X rays of Röntgen.' X rays have the power of penetrating most opaque bodies in varying degrees, and in general terms substances are opaque to X rays in proportion to the atomic weights of their constituent elements. X rays also have the power of acting upon sensitive silver salts in the same way as light, so that if a structure, such as a limb, be interposed between the source of the rays and a sensitive photographic plate, the rays will readily penetrate the softer parts; but their passage will be hindered by the more resistant structures, such as bones, which will thereby throw a shadow on the plate. Radiographs or skiagraphs are the shadow-pictures produced in this manner. The greater the vacuum in the tube, the greater will be the strength of current needed to traverse it, and the greater the penetrating power of the X rays produced. These are known as 'hard tubes.' Soft tubes are those in which less strength of current is required to produce the rays, which have a less penetrating effect, and therefore are more useful in permitting a greater differentiation of shadow.

Barium platino-cyanide and certain uranium salts are rendered fluorescent by the passage of X rays, so that, if a screen covered with one of these substances is held distal to the limb or part to be examined, a shadow similar to a radiograph is produced, and can be seen. The *radiographic screen* is of great value in many conditions as a means of rapid diagnosis, and sometimes gives better results than the radiograph, especially when absolute immobility cannot be obtained. Thus the movements of the heart, of the diaphragm, the pulsations of an aortic aneurism, etc., can be better examined by the screen than by taking a radiograph. As an illustration of this may be mentioned a case where a silver probe had slipped down through a tracheotomy wound into a bronchus. An attempt to photograph it failed completely, but on examination with the screen the probe was seen lying transversely in the left bronchus, moving up and down at each beat of the heart.

Great care is necessary in the interpretation of radiographic pictures, as, the rays being divergent, some distortion of the resulting shadows occurs, according to the distance of the object from the source, and the exact angle at which the rays impinge upon it. To avoid this deception, stereoscopic photographs, or views in two directions at right angles to one another, are necessary. Moreover, the results vary much, according to whether the radiograph is taken from before or behind. Thus, if a shoulder be radiographed from behind, with the plate in front, the details of the coracoid process and of the head of the humerus will be most clearly defined; whereas if the plate is posterior, and the picture is taken from the front, the acromion and spine of the scapula are most sharply represented. In practice the outlines of bones are clearly seen; cartilage and callus are more transparent; muscles and tendons are sometimes visible if a very soft tube is employed. Calculi vary according to their composition, oxalates being most opaque and uric acid stones most transparent. Gallstones are very seldom impervious. By the use of soft tubes the outlines of viscera, such as the liver and kidneys, may often be obtained.

2. As a **Therapeutic Agent** electricity is employed in many ways:

(1) The *galvanic and faradic currents* are employed, both generally and locally, for their stimulating action. Under the former heading one would include the use of the *electric bath*, in which a patient lies in water to which a small addition of salt is made, and through which a galvanic current is passed. The effect of this is to increase the superficial circulation and produce cutaneous hyperæmia. It is often useful in diffuse rheumatic and gouty fibrositis, as also in conditions in which the general muscular and nervous tone of the body has been lowered. It is of considerable value in the treatment of conditions depending on arterial spasm, such as Raynaud's disease. Care must be taken only to increase or decrease the strength of the current gradually, otherwise the patient may experience an unpleasant shock.

Locally the galvanic and faradic currents find their chief employment in cases of muscular paralysis, in order to prevent degeneration of muscles where the nervous control has been lost, as by division of motor nerves, and also to maintain the conductivity of the nerves where this has been impaired. The faradic current is probably more useful in this direction than the galvanic.

(2) *Electrolysis* is used chiefly for the destruction of superfluous hairs, moles, etc., the removal of nævi, and the coagulation of blood in aneurisms. The passage of a current of sufficient strength between metallic poles actually inserted into the tissues sets up an electrolytic action, and coagulation of the blood or local destruction of hair follicles, etc., results. The clot formation is most marked at the positive pole; hence it is often unnecessary actually to insert the negative needle into the tissues, but to use an ordinary flat pad, moistened with salt solution and applied to the skin away from the part to be treated. The use of the negative pole is more likely to produce scarring, since a caustic alkaline compound is formed around it, and this may lead to sloughing of the tissues; the quality of the clot produced, moreover, is loose and

spongy. In large nævi, etc., several needles attached to the positive pole are used with advantage, and should be made of platinum or steel, insulated by shellac or sealing-wax up to the point of entry through the skin, in order to protect it from the electric current; ineffective insulation results in destruction of the skin. The strength of the current employed varies according to whether both poles are introduced, or only the positive. Under the latter circumstances a current equal to about 25 to 75 milliampères should be applied for ten to fifteen minutes, care being taken to increase its strength gradually to the maximum, and similarly to decrease it. An anæsthetic is needed, and the immediate effect should be to make the mass feel hard and firm by the coagulation of the blood. Organization of the thrombus leads to obliteration of the vascular spaces and the disappearance of the tumour. Two or more sittings are usually necessary before the growth is effectively treated. Of course, some scarring is almost always left, and hence it is wise not to do too much at one sitting, and to make the intervals sufficiently long to allow of effective cicatrization.

(3) *Static electricity* generated by a machine such as Wimshurst's or Holtz's is used as a bath or brush discharge in the treatment of neurasthenia, general or nervous debility, neuralgia, and in certain chronic skin diseases, such as psoriasis, lupus, etc. It is of use rather as a general tonic than as having any specific effect. The *high-frequency* current is an induced current set up in a secondary circuit by a modified induction coil, in which Leyden jars take the place of a voltaic cell. It is said to increase metabolism and heat production, and is recommended for constitutional diseases, such as gout, diabetes, and rheumatism, etc.

(4) *Ionic medication,* or cataphoresis, consists in the introduction of drugs directly into the tissues of the body by means of an electric current. It is based on the principle that the passage of a current through a solution of a salt is accompanied by movement of the constituent ions—*i.e.*, of the atoms or molecules which are electrically charged. The positively charged ions (kations), which include those of all metals, alkalies, and alkaloids, are attracted to the negative pole, while the negatively charged ions (anions), such as those of chlorine, iodine, the acids, and hydroxyl, are attracted to the positive pole. If the human body is interposed in the current, instead of a solution of salt in a vessel, and lint pads, soaked in a solution of the salt or drug, are placed between the skin and the electrodes, kations at the positive pole and anions at the negative pole will enter the tissues and be disseminated in them for a variable distance, probably from 1 to 10 millimetres. The pads should be thick and of large area, and the strength of current 2 to 3 milliampères per square centimetre of area of the pads.

This method is chiefly used in the treatment of chronic inflammation of joints and other tissues, but good results have also been obtained in chronic ulcers, rodent ulcers, lupus, warts, etc. Zinc, copper, magnesium, iodides, and salicylates, are the drugs chiefly used; but quinine, cocaine, and adrenalin, have also been employed.

(5) *X rays* are used therapeutically in the treatment of cancer, rodent ulcer, and certain skin conditions, such as ringworm, to produce epilation; keloid scars; and also in general conditions, such as exophthalmic goitre, lymphadenoma, the leukæmias, etc. The effects will be noted under the ensuing section, dealing with radium.

Radium and Radio-Therapy.

Radium, discovered by Madame Curie in 1898, is a constituent of pitch-blende. It is mainly sold in the form of radium bromide, a hard, yellowish, crystalline substance, and is the chief of a group of elements which have a radio-active property—that is to say, they can influence a photographic plate through an opaque layer of black paper. Radium emits three types of rays, named α, β, and γ, of which the γ rays are the most penetrative and of the greatest therapeutic value.

For application, the salts of radium are contained in hermetically sealed tubes of glass, aluminium, silver, lead, or platinum, each tube containing from 5 to 100 milligrammes, or are spread on flat metal plates in definite amounts per square centimetre of surface. These are covered by lead, aluminium, or silver filters of variable thickness, in order to exclude the α and β rays, so that the γ rays may be alone utilized. It is also possible to charge water and other fluids with emanations (probably gas given off from the radium) which render them radio-active, and enable them to exercise to a limited degree similar powers. It is possible that the therapeutic value of certain mineral waters—*e.g.*, Bath—is in part dependent on the possession of radio-active properties.

Radium may be applied directly to lesions of the skin or mucous membranes, or it may be possible to influence deeper growths through healthy integument or mucous membrane; but in the latter instance it is better, if possible, to implant the radium for a time into the midst of the growth. In particular, it is of value to expose to the influences of the radium any cavity from which a surgeon is doubtful as to the complete removal of a malignant growth.

It is impossible at present to write dogmatically on the power of radium or to discuss its method of action; but certain facts are agreed on: (1) That it has a power of influencing the cells of living tissues is undoubted. If a series of suitable growing plants be exposed to radium at various distances, it will be found that it is possible to kill some that are close to it by exposures which stimulate others to richer and fuller development, whilst at intermediate distances growth is hindered. (2) This influence lies particularly in the direction of checking the growth of actively multiplying cells, and perhaps of aiding the development of the more stable elements. Hence the actual growing cells of a cancer or sarcoma are likely to be affected destructively by exposure to radium.

whereas the connective tissues of the part may by suitable dosage be stimulated to reparative activity. (3) The question of dosage and length of exposure is therefore of the gravest importance, and it is also one on which opinions differ considerably. Probably it will be wise at present to work with moderate doses, and not to employ them for too long a time. (4) What has been written concerning radium is similarly true as regards X rays; but, of course, the great distinction between the two procedures is the ready applicability of radium to the surface and into the substance of tumours, whereas X rays can only be applied from a distance.

The *results* of radium and X-ray treatment vary considerably, and at present, out of the mass of evidence accumulating on every hand, it is only possible to draw certain broad conclusions:

1. Superficial growths of various kinds are effectively and satisfactorily influenced by this means. *Warts, nævi, keloidal growths,* and similar non-malignant developments, are often cured by one exposure or application; laryngeal warts are similarly affected. *Rodent ulcer* is readily cured by either radium or X rays, and there is really nothing to choose between the two. It is unusual for operative measures to be required except when the disease has spread deeply and affected bone or cartilage. In these cases it is probable that repeated exposures to radium or X rays have depressed the vitality of the parts to such an extent as to influence the result even of operative treatment. *Cutaneous epithelioma* may be affected beneficially, but the results are not so good as in rodent ulcer, and it is quite probable that excision should be undertaken in the first place where possible, and radium treatment be employed subsequently. *Cancer of mucous membranes* is, on the whole, less favourable to treat than that of the skin.

2. Cancer of deeper organs is variously influenced by radiotherapy. There is as yet no justification for replacing operative treatment of cancer of the *breast* by this means. It is, of course, desirable to follow operation by radio-therapy, in the hope of destroying any living cells that may remain. Inoperable recurrences may also be cured by this means; and even large, hopeless growths involving the whole breast may be improved by burying radium in its substance for twenty-four to forty-eight hours, introducing it at intervals into different parts of the organ. Pain is usually relieved thereby, ulceration may be healed, and discharge diminished.

Cancer of the *mouth, tongue,* and *jaws,* may be improved locally to some extent, but recurrence in the glands and death are only too likely to end the chapter. If the glands have been effectively removed, local recurrences may be hopefully attacked. In the *Œsophagus,* a cancerous stricture may be opened up by introducing into it a tube of radium; but, although the power of deglutition may be thereby restored or retained for a longer time than otherwise, a cure is not in the least likely. Cancer of the *stomach* or *intestine* can rarely be treated by radium, as destruction of the growth may involve serious consequences, such as perforation of the bowel, thrombosis of important vessels, or grave hæmorrhage. Some cases of rectal carcinoma may be treated thereby; but permanent improvement can scarcely be expected, although some relief of pain may be experienced. Similar remarks apply to cancer of the *bladder*. *Uterine carcinoma* is undoubtedly influenced most beneficially by radium; hæmorrhage is arrested; the discharge is diminished and rendered inoffensive; ulceration is healed and pain relieved. Often the peri-uterine thickening and infiltration are absorbed to such an extent as to render operable a case previously considered hopeless. Naturally, the ultimate prognosis depends on the extent of glandular involvement, and hence, where practicable, operation is still desirable.

3. *Sarcomata* are amenable to radio-therapy to an even greater extent than cancers. It is desirable to implant the radium into their substance, and cessation of growth often follows. Periosteal or round-celled sarcomata of the long bones may be thus treated, and thereby amputation avoided; but, of course, the ultimate prognosis depends on whether or not secondary deposits have occurred in the viscera. *Myeloma* of bones can also be treated by this means, with or without erasion of the growth, and thereby in early cases amputation or excision of an important bone may be avoided.

4. Many other growths are capable of being influenced by radiotherapy—*e.g.*, lymphadenoma, tuberculous lymphadenitis, etc. These will be alluded to elsewhere.

It is important to remember that prolonged exposure to X rays produces erythematous burns which frequently lead to dermatitis, with chronic ulceration of the skin. In some cases this progresses and takes on a malignant type (X-ray cancer); this has been seen most frequently on the fingers and hands of the early workers in X rays, before the necessity of strict protection of the operator was realized.

CHAPTER IV.

EXAMINATION OF THE BLOOD IN HEALTH AND DISEASE.

ALTHOUGH an examination of the condition of the blood is frequently of great importance to the surgeon, a mere outline of the chief facts is all that can here be attempted.

The **red blood corpuscles** average about 5,000,000 to the cubic millimetre in men and about 4,500,000 in women, and are readily counted by means of the Thoma-Zeiss hæmocytometer or other similar instrument. The chief surgical value of such investigations arises in connection with hæmorrhage, for they enable us to determine the amount of blood lost at a surgical operation or as the result of a wound, and to trace the process of recovery. It is usually advisable to supplement the counting of the corpuscles by estimating the amount of hæmoglobin present by means of Haldane's or some other hæmoglobinometer, the result being expressed as a percentage of the normal amount. Thus, blood containing half the amount that should exist in a given bulk in a normal man is said to contain 50 per cent. of hæmoglobin. It is also convenient to calculate the 'corpuscular richness' or 'colour-index,' which is done by dividing the percentage of hæmoglobin by the number of corpuscles expressed as a percentage of the normal. For example, under normal conditions the hæmoglobin is 100 per cent., and there are 5,000,000 corpuscles per cubic millimetre, so that the colour-index is $\frac{100}{100}=1$. If the corpuscles have fallen to 3,000,000 (60 per cent. of the normal), whilst the hæmoglobin has fallen to 30 per cent., the colour-index is $\frac{30}{60}=0{\cdot}5$; that is to say, each red corpuscle contains only half as much hæmoglobin as it should do. In general a high colour-index is indicative of pernicious anæmia, and one which is greatly reduced of chlorosis, though in cases of severe secondary anæmia of long standing a similar reduction may be present.

If the blood is examined immediately *after* a patient has suffered from a severe *hæmorrhage*, it will naturally be found to be normal in composition; part has been lost, but the quality of the remainder has not altered. After a short time the volume of blood is restored to normal by means of fluid derived from the tissues. In this stage the blood is more diluted than normal, the red corpuscles and hæmoglobin being alike reduced, so that the colour-index remains 1. There is also in most cases a temporary increase in the number of leucocytes. The process of absorption of fluid from the tissues is imitated artificially in the infusion of saline solutions in collapse or after severe hæmorrhage, and it is found that this process has a beneficial effect in accelerating the subsequent regeneration of the blood as well as in raising the blood-pressure and removing the urgent symptoms.

In the subsequent process of recovery the red corpuscles increase more rapidly than the hæmoglobin, so that the colour-index falls somewhat. The length of time necessary for full regeneration of the blood varies greatly, the process being more rapid in men than women, and in young adults than in the old or young. Approximately 1 per cent. of hæmoglobin is regenerated per diem; thus the blood becomes normal in about twenty days after the loss of 20 per cent. of hæmoglobin if the patient is kept under favourable conditions.

It is not possible to lay down any definite rule as to the amount of hæmorrhage which is necessarily fatal. Other things being equal, a patient will survive a much greater loss of blood if it takes place gradually than if it takes place quickly. In the latter case a reduction of the hæmoglobin to 50 per cent. will probably be fatal, whereas in the former it may fall to 20 per cent., or lower, and recovery still take place. Women tolerate loss of blood better than men, and men tolerate it better than children.

Anæmic patients are usually bad subjects for operations, but it is not possible to formulate any rule for the guidance of the surgeon as to the degree of anæmia which should make him unwilling to operate.

It is important to notice that a high degree of anæmia occurs in acute spreading inflammation, septic fever, septicæmia, etc., and this fact is occasionally of diagnostic value. The diminution of the corpuscles and hæmoglobin usually occurs rapidly, sometimes with a rapidity only second to that which occurs after severe hæmorrhage, and gives rise to a severe form of secondary anæmia. The colour-index is usually low, the hæmoglobin being destroyed more rapidly than the corpuscles.

The examination of the **leucocytes** is often of the greatest importance. It comprises an enumeration of the total number per cubic millimetre, and a differential count of the relative number of the various kinds. The former examination is carried out by a method similar to that used in counting the red corpuscles, and, as it takes but a few minutes and requires but little practice, should be learnt by all surgeons. The differential count is made on thin films of blood, which are dried and stained by a double or triple stain, Jenner's stain being the simplest and most useful.

Jenner's stain consists of a solution of eosinate of methylene blue in methyl alcohol. To use it the blood film is allowed to dry spontaneously and is then flooded with the stain, which is allowed to act for about two minutes. It is then poured off, and the film is rinsed in distilled water for a few seconds, drained, allowed to dry spontaneously, and mounted in Canada balsam. This is then examined under a $\frac{1}{6}$ inch lens, each leucocyte seen being noted down, until 400 or more have been counted. The results are reduced to percentages.

In health the blood contains from 4,000 to 10,000 leucocytes per cubic millimetre, five different forms of cell being present—the polynuclear leucocyte, the eosinophile leucocyte, the mast-cell, the lymphocyte, and the hyaline cell. Of these, the first three contain definite granules in their protoplasm, the others do not. In the following description we assume that the film has been stained by Jenner's method. If other staining processes are used, the colours of the various structures will naturally be somewhat different.

1. The *polynuclear* or *polymorphonuclear leucocyte* (Fig. 12, *c*) is rather larger than a red corpuscle. It is characterized by having a twisted or indented nucleus, which in badly prepared specimens may appear to be multiple, although with proper preparation and the use of high powers of the microscope the connecting filaments between the various parts can always be made out. It contains in its protoplasm numerous very minute granules which have an affinity for acid stains, and hence are coloured pink by the eosin in Jenner's stain. In specimens which have not been well stained these granules may not be visible, but the cell can always be identified by its nucleus.

The polynuclear leucocytes are the chief phagocytic cells of the blood, being actively amœboid and endowed with the power of ingesting bacteria or other small objects. They are formed, mainly or entirely, in the bone-marrow, and constitute in health from 65 to 75 per cent. of all the leucocytes.

2. The *eosinophile leucocytes* (Fig. 12, *d*) are about as large as the foregoing, and have a bilobed or polymorphous nucleus. They have also granules which stain with eosin, but these are much larger and more defined than those of the polynuclears.

The eosinophiles form 2 to 4 per cent. of the leucocytes of normal blood. They are probably formed partly in the bone-marrow and partly in other connective tissues. They are feebly mobile, and their functions are not definitely known.

3. The *mast-cells* (Fig. 12, *e*) have lobed nuclei and granules which stain with methylene blue, though usually metachromatically, taking a purplish colour. They are present in very small proportions (about $\frac{1}{2}$ per cent.) in normal blood, and their functions are unknown. They are connective-tissue cells, and are often present in considerable numbers in inflamed tissues.

4. The *lymphocytes* (Fig. 12, *a*) are devoid of granules, and their nuclei are not polymorphous. They vary in size, but the majority are rather smaller than the red corpuscles. Each lymphocyte has a single circular nucleus which is situated centrally; this is sur-

rounded by a narrow zone of protoplasm, which in suitably stained specimens takes the methylene blue more deeply than does the nucleus itself.

Lymphocytes constitute 20 to 25 per cent. of the leucocytes of health. In children the proportion may be much higher, the polynuclears being correspondingly reduced. They are formed in the lymphatic glands, spleen, Peyer's patches, and lymph-adenoid tissue generally. They are probably identical with the 'small round cell' which is so characteristic of non-suppurative inflammatory foci, and in these lesions we have reason to believe that they can be produced locally in any part of the body, probably by a process of budding from the endothelial cells.

5. The *large hyaline or large mononuclear cells* (Fig. 12, *b*) vary in size, but as a rule are decidedly larger than the red corpuscles. They have a single circular, oval, or kidney-shaped nucleus, which is smaller relatively to the cell than the nucleus of the lymphocyte.

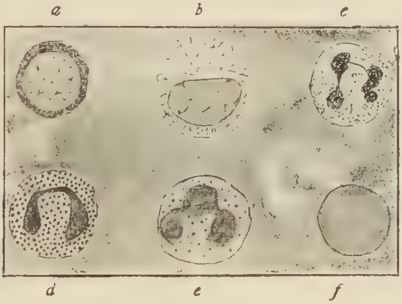

Fig. 12.—Corpuscular Elements of Normal Blood. (Emery.)

a, Lymphocyte; *b*, hyaline or large mononuclear cell; *c*, polynuclear leucocyte; *d*, eosinophile cell; *e*, mast-cell; *f*, red corpuscle, to show the relative sizes of the other cells.

The protoplasm stains faintly with methylene blue. It is devoid of granules, but often shows bluish points, which are really nodal thickenings of the reticulum. These cells form 2 to 4 per cent. of the leucocytes of normal blood, and have considerable powers of phagocytosis. Their origin and relation to the lymphocytes is not definitely known, but there is some reason for regarding them as endothelial cells which have been detached from the walls of the vessels.

An increase of the total leucocytes present in the blood is termed *leucocytosis*. Under most circumstances this increase is mainly due to an increase in the number of polynuclears present; special terms are used for an increase of other forms of leucocytes. An increase in the eosinophiles is called *eosinophilia*, and an increase in the lymphocytes is called *lymphocytosis*. A diminution of the leucocytes is termed *leucopenia*.

Leucocytosis occurs under *physiological* conditions during digestion, during pregnancy, and in the new-born infant. This has to be remembered in interpreting leucocyte counts in disease. The former factor is of especial importance, and if possible the blood should be collected whilst the patient is fasting.

Pathological leucocytosis occurs in many conditions, the most important being the infective diseases, and in these the highest counts are met with in pneumonia and in *suppuration*. The latter is of special importance to the surgeon, as the presence of a high leucocytosis may be regarded as the most definite single sign of the presence of pus. It is especially valuable in *appendicitis*, where the other evidences of suppuration are often equivocal. When no pus is present, the blood shows slight leucocytosis, the number not usually exceeding 15,000 per cubic millimetre. When pus is present the number is much greater, being usually not less than 18,000, and it may rise as high as 50,000, or even higher. For practical purposes a count of 20,000 leucocytes per cubic millimetre may be taken as an almost certain proof of suppuration, presuming, of course, that the other causes of lecocytosis can be excluded. Figures between 15,000 and 20,000 are not sufficiently definite to be of much value, and where they are obtained it is advisable to repeat the examination in twenty-four hours. If suppuration is taking place, the count will almost certainly rise, whilst if it remains at the same level, or shows a decline, the presence of pus is unlikely. The height of the leucocytosis gives no indication of the size of the abscess or of the rapidity of its spread.

The opening of the abscess is usually followed by a fall in the number of leucocytes, and this is so rapid as to be quite definite in the course of twelve hours. When it does not take place, the probability is that a second abscess is present, which was overlooked at the time of the operation.

The absence of leucocytosis is presumptive evidence that suppuration has not occurred, but several facts have to be considered in applying this rule in actual practice:

1. The cause of the leucocytosis is the passage of the bacterial products from the inflammatory focus to the blood-stream, where they exert a positively chemotactic action, attracting the leucocytes from the bone-marrow, whilst at the same time they stimulate the latter to an increased production of leucocytes. As long as the abscess remains unopened and is spreading, these substances gain access to the blood-stream with ease, for it is the only path available to them. But when the abscess is opened so that the pus laden with bacterial toxins can drain away, the leucocytosis falls, even although the abscess may burrow for a time. An example of this was seen in a patient suffering from appendicitis, in whom there were very doubtful clinical indications of pus, and who showed a leucocytosis of 38,000; this was regarded as definite proof of the existence of an abscess. A few hours after the count was made the patient suffered from diarrhœa, and pus was found in the stools. A second

count was made forty-eight hours after the first, and the leucocytes were found to have fallen to 13,500, yet at the operation a large abscess cavity with extensive ramifications was found. If the patient had been admitted to the hospital after the rupture of the abscess into the intestine, the leucocyte count would have led to an erroneous conclusion. For a similar reason—viz., the non-absorption of toxins into the blood—there is but slight leucocytosis in suppurative inflammation of the mucous membranes.

2. When the pyogenic bacteria have been killed, the toxins are soon carried away in the blood-stream and eliminated from the body, and when this has happened the leucocytosis falls, although there is still a collection of pus in the tissues. In other words, a high leucocytosis is to be regarded as a proof of the process of suppuration rather than as a proof of the presence of pus. For example, such sterile collections of unabsorbed pus often occur in cases of pyosalpinx of some standing, and are unaccompanied by leucocytosis, although acute suppuration in the Fallopian tubes causes the usual reaction.

3. When the organisms are very virulent and the patient of feeble constitution, so that the infection rapidly spreads, there is occasionally a failure of leucocytosis or even a leucopenia. This is notably the case in severe cases of diffuse septic peritonitis. The general (as well as the local) leucocytosis must be regarded as a conservative and defensive reaction, whatever views are held as to the nature of immunity. Its presence indicates that the patient has sufficient resisting powers to combat the infection, or at least to localize it for a time; its absence in a case where there is suppuration renders the prognosis unusually bad.

4. Leucocytosis does not occur in cases of chronic or cold abscess. The products formed by the bacteria which produce these lesions have no positive chemotactic action on the polynuclear leucocytes. The cells found in the local lesions are mostly lymphocytes. Hence, even when the toxins of these organisms enter the blood, they fail to attract the polynuclear leucocytes from the marrow. We might reasonably expect that an increase in the lymphocytes would occur; but these cells are not actively motile like the polynuclears, and are not so readily subservient to chemotactic influences.

Another method sometimes used in the diagnosis of suppuration is based on the appearance of granules of glycogen (or an allied substance) in the protoplasm of the leucocytes in septic diseases. Dry blood-films are mounted in a recently prepared solution of iodine 1, iodide of potassium 3, water 100, which has been saturated with powdered gum acacia. This stains the granules deep brown. This test is not as useful as the foregoing.

The relations of some of the other infective diseases to the leucocytes may be briefly epitomized. In pneumonia, erysipelas. diphtheria, scarlet fever, plague, and whooping-cough there is a high leucocytosis, the number rarely falling below 20,000. In rheumatic fever (uncomplicated), syphilis, and gonorrhœa there is usually a slight rise, and in tuberculosis, typhoid fever, influenza, measles, and malaria there is usually no excess, and often a diminution, in the number of leucocytes (leucopenia).

Pathological leucocytosis also occurs after severe hæmorrhage, and in all cachectic conditions, especially in that due to malignant disease. In these cases it is almost always due to a local inflammation excited by the new growth, and is rarely of diagnostic value. In carcinoma of the stomach there is usually an absence of digestion-leucocytosis, and this fact may assist in the diagnosis. The leucocytes are counted whilst the patient is fasting, and two or three times (at intervals of an hour) after a meal, which should include some meat. If the count does not rise considerably (2,000 per cubic millimetre or more), it affords strong presumptive evidence of the presence of malignant disease of the stomach, but, like all laboratory tests, must be considered in conjunction with the clinical phenomena.

Lymphocytosis, or an increase of the lymphocytes, may be absolute or relative. A relative increase (*i.e.*, such that the percentage of these cells rises above 25, although the total number of leucocytes of all sorts does not exceed the normal) occurs in typhoid fever, tuberculosis, and malaria. A great excess of leucocytes (150,000 or more per cubic millimetre), the great majority being lymphocytes, occurs only in lymphatic leucocythæmia, and constitutes an important means of diagnosis between this condition and Hodgkin's disease, in which the leucocytes are normal or but slightly increased. Children's blood contains an excess of lymphocytes, reaching 60 per cent., and in inflammatory diseases of children the increase in the total leucocytes may be due partly to an excess of lymphocytes, and not only of the polynuclears, as in the adult. This is especially the case if the lymph-glands are involved in the inflammatory process.

Eosinophilia, *i.e.*, a relative increase of the eosinophiles, occurs in several conditions: (1) In infection with animal parasites, especially in trichinosis, where the proportion may be 60 per cent. or more. They are sometimes increased in hydatid disease; in doubtful cases this fact has some diagnostic value, but a count in which there is no increase is of little importance. (2) In some skin diseases, especially when a large area of skin is involved. (3) In asthma. (4) In gonorrhœa, and a few other diseases.

A brief account of the blood conditions in those diseases which are especially connected with the blood-forming organs may be of some value:

1. In *pernicious anæmia* the corpuscles are greatly reduced in numbers, whilst the hæmoglobin is reduced, but to a lesser extent, the colour-index being greater than 1. The red corpuscles are often distorted in shape (poikilocytosis), and large (megalocytes) or small (microcytes) forms occur. Large nucleated red corpuscles (megaloblasts) are usually present, and are almost diagnostic of the disease. The leucocytes are usually normal or subnormal in number, and there is a relative increase of lymphocytes.

2. In *chlorosis* the hæmoglobin is reduced to a greater extent than the corpuscles, the colour-index being less than 1. There may be some microcytes, but the red corpuscles are usually normal in shape and size, though of pale colour. The leucocytes are usually normal.

3. In *spleno-medullary leucocythæmia* there is an enormous increase in the leucocytes; the number is usually not less than 100,000 per cubic millimetre, and may rise to 1,000,000 or even more. Of these a large proportion are myelocytes, cells which do not occur in normal blood. They vary in size, but are usually large, and may be very large; they have a single nucleus, which stains badly and is circular, oval, or indented, and often excentrically placed; they contain granules similar to those of the polynuclear leucocytes. The eosinophile cells are greatly increased in absolute numbers, though their proportion relatively to the other cells may be normal. Eosinophile myelocytes also occur; they are similar in all respects to the myelocytes, except that their granules are large, resembling those of the eosinophiles of normal blood. The polynuclears are present in vast numbers, but their relative proportion is less owing to the number of the myelocytes. The lymphocytes are scanty, but the mast-cells are often abnormally plentiful. Nucleated red corpuscles occur.

4. *Lymphatic leucocythæmia* can be distinguished from Hodgkin's disease (lymphadenoma) only by an examination of the blood. In the former disease there is a vast number of leucocytes, the great majority (90 per cent. or more) of which are lymphocytes. In the early stages of Hodgkin's disease the blood is absolutely normal, whilst later there is marked anæmia. The leucocytes are not usually increased in numbers, and there may be leucopenia; there is often a slight relative increase in the lymphocytes. In some cases there is leucocytosis. Hodgkin's disease cannot be differentiated from tuberculosis of the lymphatic glands by a blood count alone.

The examination of the blood for parasites (including bacteria) is often necessary. It may be carried out by microscopic examinations of fresh blood or blood-films, or by cultures; the method to be selected must depend upon the organism sought.

The diagnosis of *malaria* may be made by an examination of a wet film of fresh blood made by taking a small drop of the blood on a perfectly clean cover-glass, and placing the latter, drop downwards, on a perfectly clean slide; or films may be prepared in the ordinary way and stained by carbol-thionin, hæmatoxylin and eosin, Jenner's stain, or by other methods. For a description of the organisms and their life-history the reader is referred to special treatises.

Relapsing fever is due to a corkscrew-like organism (the *Spirillum Obermeyeri*), which is about two or three times as long as the diameter of a red corpuscle. They may be demonstrated by the method used for the malaria parasite, and in fresh specimens are as a rule actively motile.

The diagnosis of *filariasis* is best made by examining with a low-power lens thick layers of fresh blood taken at night, if *F. nocturna* is suspected; in the daytime, in the case of *F. diurna ;* and at any time if *F. perstans* is sought.

Where bacteria are sought for in the blood, cultural methods are almost always necessary, for their numbers are usually so small that the chance of finding even a single specimen in a stained blood-film is remote. The blood must be drawn directly from a vein with a sterilized hypodermic needle and syringe (or better with a hypodermic needle mounted on a short length of glass tubing and the whole sterilized by heat), and full precautions must be taken in sterilizing the skin. At least 3 or 4 c.c. should be taken and inoculated directly into broth or melted agar, which is incubated and examined at the end of twenty-four and forty-eight hours. It is worse than useless to attempt to make a bacteriological examination of blood obtained from a skin puncture, however carefully the skin may have been sterilized.

In septicæmia, pyæmia, ulcerative endocarditis, and other diseases due to the pyogenic bacteria, the organisms may or may not be found in the blood. A positive result is most likely to be obtained in severe cases, especially when the blood is collected during a rigor; it is of evil omen, although such cases are by no means necessarily fatal. Cultures in which staphylococci are the only organisms to develop must be interpreted with caution, as being possibly due to accidental contamination. A negative result is usually of little value in diagnosis, as organisms may be absent from the blood for long periods in cases of chronic septicæmia.

It is sometimes necessary to examine the blood for bacteria in the diagnosis of *typhoid fever*, especially when the infection is not due to the ordinary typhoid bacillus, but to one of its congeners (the paratyphoid bacillus, etc.). In general, the diagnosis is made by means of Widal's reaction.

Typical Blood-Counts.

It must be understood that the series of blood-counts here appended are to be looked on merely as typical illustrations; in any particular instance considerable differences from the figures given may be manifested.

Normal Blood—

Red corpuscles	5,120,000 per c.mm.
Hæmoglobin	100 per cent.
Colour-index	1 (nearly).
Morphology of red corpuscles	No abnormal forms seen. Corpuscles uniform in size, and stain only with the acid stain (eosin)

Normal Blood—*continued :*

Leucocytes	7,000 per c.mm.
Polynuclears	72·0 per cent.
Lymphocytes	22·8 ,,
Eosinophiles	2·4 ,,
Large hyalines	2·4 ,,
Mast-cells	0·4 ,,

No other forms of leucocytes seen.

Secondary Anæmia from repeated slight hæmorrhages—

Red corpuscles	4,200,000 per c.mm.
Hæmoglobin	72·00 per cent.
Colour-index	·85

Secondary Anæmia—*continued :*

Morphology of red corpuscles	Corpuscles stain a little faintly; no nucleated forms seen.

(N.B.—In severer cases of secondary anæmia, and especially in cases of profound anæmia after a single large hæmorrhage in a previously healthy person, normoblasts may be seen, and are a good sign.)

Malignant Disease with cachexia—

Red corpuscles	3,200,000 per c.mm.
Hæmoglobin	48·00 per cent.
Colour-index	·75
Morphology of red corpuscles	The corpuscles stain somewhat faintly; normoblasts are present, but in scanty numbers.
Leucocytes	12,000 per c.mm.
Polynuclears	82·4 per cent.
Lymphocytes	14·8 ,,
Large hyalines	1·8 ,,
Eosinophiles	·6 ,,
Mast-cells	·4 ,,
Morphology of leucocytes	Nothing abnormal seen.

Suppuration (acute appendix abscess)—

Red corpuscles	4,500,000 per c.mm.
Hæmoglobin	85·00 per cent.
Colour-index	·95
Morphology of red corpuscles	Normal.
Leucocytes	23,000 per c.mm.
Polynuclears	86·2 per cent.
Lymphocytes	11·6 ,,
Eosinophiles	1·0 ,,
Large hyalines	1·2 ,,

No abnormal forms seen. Some of the polynuclears show 'glycogenic' degeneration.

Tubercle (not complicated with secondary infections)—

Red corpuscles	4,112,000 per c.mm.
Hæmoglobin	76·0 per cent.
Colour-index	·9
Morphology of red corpuscles	Normal.
Leucocytes	4,200 per c.mm.
Polynuclears	64·2 per cent.
Lymphocytes	32·8 ,,
Large hyalines	2·8 ,,
Eosinophiles	·2 ,,
Morphology of leucocytes	Normal.

Lymphatic Leucocythæmia—

Red corpuscles	2,600,000 per c.mm.
Hæmoglobin	36·0 per cent.
Colour-index	·7
Morphology	The corpuscles stain somewhat faintly; normoblasts are present, but in scanty numbers.
Leucocytes	112,000 per c.mm.
Polynuclears	8·2 per cent.
Lymphocytes (nearly all small)	91·2 ,,
Eosinophiles	·4 ,,
Myelocytes	·2 ,,

(N.B.—In lymphatic leucocythæmia there is not necessarily a great total increase in the number of the leucocytes, but the relative increase in the lymphocytes is usually very marked.)

Leucocythæmia (spleno-medullary)—

Red corpuscles	3,200,000 per c.mm.
Hæmoglobin	52·0 per cent.
Colour-index	·8
Morphology of red corpuscles	Normoblasts present in rather large numbers (about one in every two fields of a ⅙-inch lens).
Leucocytes	456,000 per c.mm.
Myelocytes and cells intermediate between them and polynuclears	42·0 per cent.
Polynuclears	39·0 ,,
Eosinophiles and eosinophile myelocytes	8·4 ,,
Mast-cells and mast-cell myelocytes	7·6 ,,
Lymphocytes and large hyalines	3·0 ,,

Many of the polynuclear leucocytes show signs of degeneration, having faintly stained nuclëi and few granules; some are difficult to distinguish from myelocytes. Some of the myelocytes are also deficient in granules, and almost indistinguishable from large hyaline leucocytes.

CHAPTER V.

NON-SPECIFIC* PYOGENIC INFECTIONS.

In this chapter we propose to deal with a series of affections associated with or allied to suppuration, and due to non-specific bacteria. These organisms, usually termed *pyogenic*, cause an inflammatory reaction in the tissues, which sooner or later is associated with liquefaction of both tissue and exudate, the liquefied material being known as *pus*, and the process which leads to its formation as *suppuration*. Any localized collection of pus in the tissues is known as an *abscess*, and this, according to its course, may be acute or chronic, the latter being uncommon. Sometimes the infection involves the cellular tissue of a part in a more or less diffuse manner, the pus burrowing widely; this condition is termed *cellulitis*. Constitutional phenomena are associated with these local manifestations, and may be of two types: (*a*) When toxic products alone are absorbed, resulting in *toxæmia* or some modification of the same; and (*b*) when the bacteria invade the blood-stream and become disseminated to distant parts, thereby giving rise to either *septicæmia* or *pyæmia*. Each of these various conditions must be dealt with separately, but one must first describe in some little detail the organisms common to the whole group.

Bacteriology.—The following are the more important *pyogenic bacteria :*

1. The *Staphylococcus pyogenes* (Plate I., Fig. 1) is perhaps the most common organism of acute localized suppuration, especially in connection with the skin and subcutaneous tissues. It is a coccus of medium size which occurs in the pus in characteristic clusters, which have been compared to bunches of grapes. It stains by Gram's method, and liquefies gelatin or solidified blood-serum, as it produces a powerful peptonizing enzyme, and is readily cultivated on almost all media; it grows best when an abundant supply of oxygen is present.

Cultures on solid media develop rapidly, and the colonies spread, the surface being soon covered by a uniform thickish film of growth. This may be orange-yellow, lemon-yellow, or white in colour, and three organisms—*Staphylococcus pyogenes aureus*, *citreus*, and *albus*, respectively—have been recognised. Under certain circumstances, however, the one may change into the other, and there is little doubt that the three really constitute one species.

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* For the significance of the term *non-specific*, see p. 12.

Staphylococci are very widely distributed, being common in air, dust, etc. They are frequently found in or on the human skin, though apparently not normal inhabitants of that structure. Suppurative inflammations of the skin and subcutaneous tissue are due to staphylococci in the vast majority of cases; and when the inflammation is caused by other organisms in the first instance, a secondary infection with staphylococci almost always takes place later. Impetigo contagiosa, a disease due primarily to streptococci, may be taken as an example of this, and the vesicles of small-pox or vaccinia another, for in each case a secondary staphylococcic invasion takes place. The chief skin lesions due to staphylococci are abscesses, boils, carbuncles, pustular acne, etc. In some cases diffuse spreading cellulitis depends on the same cause, but this is unusual. Deep-seated suppuration, such as osteomyelitis, peritonitis, empyema, etc., may also be due to staphylococci; in fact, they may cause suppuration in any part of the body. Lastly, staphylococcic septicæmia, pyæmia, and ulcerative endocarditis occur, but are less common than the forms due to streptococci, and the prognosis appears to be slightly less grave.

Most cases of suppuration occurring after operations in which the antiseptic or aseptic precautions have been inadequate are due to staphylococci, either alone or in admixture with other organisms.

2. The *Streptococcus pyogenes* is an organism in which the individual cocci are arranged in longer or shorter chains (Plate I., Fig. 2). It stains with Gram, and does not grow very easily on artificial culture media. A temperature approximating to that of the body is desirable, and hence it does not grow well on gelatin. The colonies are small and translucent, and do not tend to spread or become confluent. It forms no peptonizing enzyme, and hence does not liquefy solidified blood-serum. The cultures readily die out.

On comparing cultures of *Streptococcus pyogenes* from different sources, slight differences may be noted, *e.g.*, in the length of the chains, the size of the cocci, the appearance of the colonies, etc. It is as yet uncertain whether these are sufficient to differentiate several species, or whether they merely indicate unimportant (and perhaps not permanent) varieties of a single species.

The *Streptococcus pyogenes* is, on the whole, a more virulent organism than the staphylococcus, and tends to produce an acute spreading inflammation rather than a localized abscess, although the latter lesion is quite commonly due to it. Erysipelas is (in most cases) caused by a streptococcus which has been held to be a distinct species, although the differences are so unimportant that the two are generally considered identical. Cellulitis, too, is usually due to the *Streptococcus pyogenes*. The organism plays its most important rôle, however, in connection with septicæmia and pyæmia, whether puerperal or not, and is the usual cause of ulcerative endocarditis,

3. The *Pneumococcus* (Plate I., Fig. 4), generally present in lobar pneumonia, is a diplococcus, the individual cocci having usually a triangular or lancet shape, with the bases facing one another. When it occurs in pus or other animal fluids, it is surrounded by a clear capsule. In cultures it closely resembles the *Streptococcus pyogenes*. It is chiefly of importance in suppuration connected with the lungs, especially empyema. It occurs almost constantly in all inflammatory lesions of the lung, whatever their origin, as a secondary infection; thus, in the walls of a tuberculous cavity suppuration is nearly always due to pneumococci alone or in conjunction with other organisms. It is a common cause of middle-ear disease, and of its cranial or intracranial complications. Pneumococci also cause arthritis, which may or may not result in suppuration; the arthritis usually follows an attack of pneumonia, but this is not necessarily the case. Peritonitis is also due to this organism in young children, and may be primary or secondary to some pulmonary lesion. The pneumococcus frequently enters the blood and causes septicæmia, with or without ulcerative endocarditis.

4. The *B. coli communis* (Plate III., Fig. 30) occurs in great numbers in the contents of the healthy intestine. It is a short motile bacillus which does not form spores, and is not stained by Gram's method. It grows best in presence of oxygen, but is a facultative anaërobe; no peptonizing enzyme is produced, so that gelatin is not liquefied, but an abundance of foul gas is developed. The *B. coli* is one of the most important putrefactive organisms, and it breaks down proteids, forming indol and allied bodies, and gases with fæcal odour. It is closely allied to the typhoid bacillus, and is distinguished therefrom by its action on various sugars; thus, the typhoid bacillus produces acid, but no gas, when grown in broth containing glucose, whereas the *B. coli* produces both acid and gas. These two bacteria are members of a large and important group of micro-organisms which have a close morphological resemblance to one another, but differ in their chemical activities.

Under normal conditions the bacilli of this species, which occur in the intestinal contents, are not very virulent, but when any pathological condition arises in the gut—*e.g.*, strangulation, ulceration, perforation, etc.—their virulence appears to be increased, and an active invasion of the tissues may follow. It is thus a common cause of appendicitis, acute peritonitis, etc., and pus due to its action has usually a fæcal odour. It can also ascend the bile-ducts, and give rise to cholecystitis and cholangitis. Lastly, the *B. coli* is one of the commonest causes of cystitis. It has, however, no power to render the urine alkaline; this is due to the presence of a micrococcus, formerly known as *M. ureæ*, but now believed to be identical with *M. epidermidis albus*, an organism of constant occurrence in the skin.

5. The *typhoid bacillus* (Plate III., Fig. 25) sometimes causes abscesses, especially in connection with the bones or joints, after an attack of typhoid fever. In some cases the organism may lie latent for years before suppuration occurs. It has also been proved that

some persons continue to give off these bacilli in the urine or fæces for many years after an attack of typhoid fever; in the latter instance the gall-bladder has sometimes been the infected focus. These 'typhoid carriers,' as they are termed, may at any time initiate an epidemic of the disease, which may thus appear to arise without reason.

6. The *B. pyocyaneus* is a comparatively rare cause of suppuration. The pus produced by it turns bluish-green when exposed to the atmosphere. It sometimes gives rise to a general infection.

7. The *Gonococcus* (see p. 142).

8. The *M. tetragenus*, an organism in which the individual cocci occur in tetrads, is rarely met with.

Many cases of suppuration are due to a *mixed infection* with two or more of the species of bacteria enumerated above. In other instances an abscess formed by the action of one of the pyogenic bacteria may be subsequently inoculated with simple saprophytes that have the power of growing in dead pus, but cannot invade the living tissues. This accident is very likely to occur in a large abscess when the drainage is insufficient and the dressings are not performed with sufficient care. It should be studiously avoided, for lesions due to a mixed infection heal with difficulty; the tissues appear more easily to acquire immunity to a single organism than to two or more at the same time. The fact that a wound is already infected is no reason for neglecting to treat it with the fullest antiseptic precautions.

I. Acute Abscess.

Ætiology.—(*a*) It may be taken as established that *suppuration* as met with in surgical practice is *always due to the action of bacteria.* It is true that in the laboratory it is possible to obtain aseptic suppuration in animals by the use of chemical irritants, such as croton oil, etc., but this does not occur in man. It is also true that in certain abscesses, notably in the liver and in pyosalpinx, no organisms can be found in the pus on microscopical or cultural examination; this is usually due to the fact that the bacteria have been destroyed and the abscess has ceased to spread. In other cases the organisms may be present in very small numbers, or may not grow on the ordinary culture media; and in this connection it may be well to point out that new varieties of pathogenic bacteria are frequently being discovered.

(*b*) *Bacteria can reach the area which becomes inflamed either from without the body or from within.* The former method is the more usual, and is illustrated by the observations of Garré and Bockhardt, who rubbed cultures of *Staphylococcus pyogenes aureus* into the skin of their arms, and produced acute suppuration, commencing in superficial pustules, and finishing as boils or carbuncles. The *Staphylococcus pyogenes* is commonly present in the skin, and frequently deposited on instruments, dressings, etc., from the air, and it is to infection from without, due to bacteria gaining access from one or other of these sources, that the majority of cases of suppuration are due.

In some cases, however, bacteria may gain access to the tissues from the blood; thus it sometimes happens that a deep lesion (such as a ruptured muscle or ligament) results in suppuration, although the skin over it is unbroken, and the intervening tissues are apparently healthy. Here we must assume the possibility of *auto-infection* (p. 7), the bacteria reaching the blood from some focus of chronic suppuration, such as a neglected pyorrhœa, or ulceration of the mouth or intestine.

In other cases abscesses may be due to organisms which have lain *latent* in the tissues, it may be, for long periods. This is never very easy to prove, but the possibility of such latency is shown by the fact that a patient may develop leprosy many years after exposure to infection. A more common example may be seen in the bone abscesses which sometimes develop months or years after an attack of typhoid fever, and which are due to the typhoid bacillus, though in this case we cannot exclude the possibility of a subsequent infection with the same certainty as in the case of leprosy. In what state the bacteria lie latent in the tissues and the nature of the conditions which excite them into activity are unsolved problems; we should expect the latter phenomenon to be due to general ill-health or to local injury, but cases occur in which no such factors can be traced. It is probable that they would regain their activity if an operation took place in the region in which they were deposited; suppuration would then follow in spite of perfect asepsis.

Abscesses of a very different nature occur when pyogenic bacteria are carried from a suppurative lesion in one part of the body to another; these are termed *secondary embolic abscesses* and develop in pyæmia, gonorrhœa, etc.

(*c*) *Sterilized foreign bodies* (*e.g.*, silver wire or glass splinters) *do not produce suppuration*, except in the rarest of cases, by auto-infection. Thus, a ragged splinter of glass, 1¼ inches long and 1½ inches wide, the result of the bursting of a soda-water bottle, was cut out of the neck of an hotel porter ten months after it had entered; it was encapsuled and had caused no trouble. This fact is constantly made use of at the present day in surgical practice; deep layers of the tissues are brought together by carefully sterilized buried sutures, and divided structures such as bones, ligaments, etc., are approximated and held in position by wire, screws, pegs, or other buried appliances, which would cause endless trouble but for their complete sterilization.

In conclusion, therefore, although we have to admit that suppuration may be experimentally induced in animals in the absence of micro-organisms, *in man for all ordinary conditions suppuration does not occur apart from the presence and vital activity of pathogenic bacteria.*

The **causes** of an acute abscess may be grouped for practical purposes under the three following headings: (1) The individual affected is possibly in a depressed and unhealthy state, and the germicidal power of his tissues may be defective. When abscesses have occurred more than once in the same individual, one may rightly suspect the existence of some intrinsic source of infection, such as oral sepsis, or some external contamination, as from defective drains, leading to escape of sewer gas. (2) A local nidus must exist, which is in a condition of lowered vitality from injury, cold, or otherwise; and (3) this spot becomes infected with pyogenic organisms brought to it either from within or without the body.

Formation and Structure of an Acute Abscess.—The bacteria which have gained access to the tissues grow and produce toxins that are diffused into the surrounding structures, giving rise to acute inflammation; the vessels dilate, acceleration of the blood-stream occurs, and is followed by retardation and thrombosis, and the leucocytes emigrate. More vigorous action of the toxins on the injured tissues destroys their vitality, usually by a process of coagulation-necrosis. A section through the lesion at this stage will show two well-differentiated zones (Fig. 13): a central area in which the tissues are dead, have lost their staining properties, and contain the pyogenic bacteria; and a peripheral zone of ordinary acute inflammation, which fades gradually into the surrounding healthy tissues. This inflamed zone is thickly infiltrated with leucocytes,

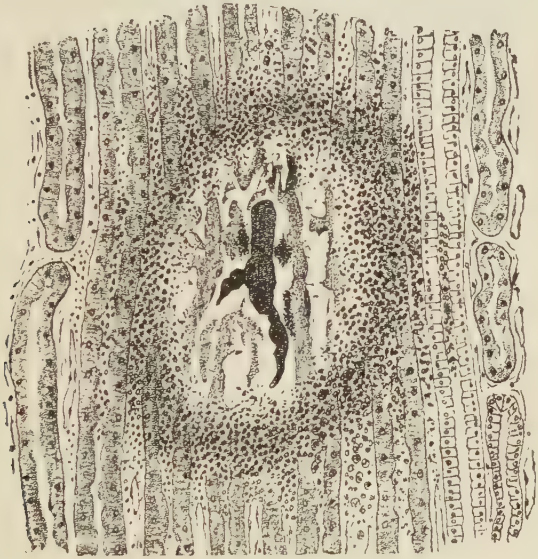

FIG. 13.—FORMATION OF ABSCESS IN THE KIDNEY. (THOMA.)

In the centre is a zooglœa mass of organisms; around it, a zone of devitalized tissue; and, still farther out, an infiltration of the living tissues with polynuclear leucocytes.

and on examination these will be found to be mainly of the polynuclear variety, since the products of pyogenic bacteria have special attractive (chemotactic) powers over this form of leucocytes.

The central necrotic mass which contains the bacteria is at this stage still attached to the surrounding living tissues, and if the lesion is incised it will appear as a small slough, which can only be removed with difficulty. But this condition soon changes; as a result of increasing exudation, especially of plasma, the tension in the inflammatory focus becomes so great that the cohesion of the tissues around the central slough is destroyed, and a third zone—of polynuclear leucocytes swimming in fluid—is formed between it and the inflamed outer zone. Where the toxins have a peptonizing enzyme action, it is possible that this plays some small part in liquefying the tissues.

The fate of the small slough varies according to circumstances. It may occasionally be recognized when a small abscess is opened —*e.g.*, the core of a boil—but in most cases it is absorbed by the leucocytes or digested by the peptonizing enzymes which many pyogenic bacteria form. It may even happen that no definite slough is ever formed (Fig. 14), the earliest effect of the bacteria being to attract the leucocytes in vast numbers into inflamed but still living tissues, which are then killed and digested cell by cell.

This collection of leucocytes suspended in fluid and surrounded by a zone of inflamed tissue constitutes an *abscess*. The leucocytes and fluid are collectively termed *pus*, and it is important to recognise that the characteristic cells of the pus from an acute abscess are the polynuclear leucocytes. These, however, differ somewhat from those seen in blood-films. Many of them are killed by the toxin (as can be seen from their loss of motion when the fresh pus is examined on a warm stage), and undergo various degenerative changes. Some of them may contain bacteria.

At first the abscess often extends rapidly, but after a day or two (in most cases) a certain amount of local immunity is produced, and the abscess spreads more slowly. This is an indication of the fact that the tissues, which were at first overwhelmed by the action of the bacteria and their toxins, are now carrying on the contest on more even terms. At this period the cavity becomes lined by *granulation tissue* (Fig. 15), which forms a thick, soft layer of velvety appearance and bright-pink colour. It is composed of large numbers of loops of newly-formed bloodvessels embedded in a mass of leucocytes and tissue-cells in a state of active proliferation. Its appearance does not necessarily indicate that the abscess has entirely ceased to spread, for the toxins may still be powerful enough to kill the delicate newly-formed tissue cell by cell; but in most cases it is the first indication of repair and of the ultimate victory of the tissues. Leucocytes continue to pass from the thin-walled vessels of new formation into the abscess cavity, being attracted chemotactically by the substances present in the pus; hence the layer of

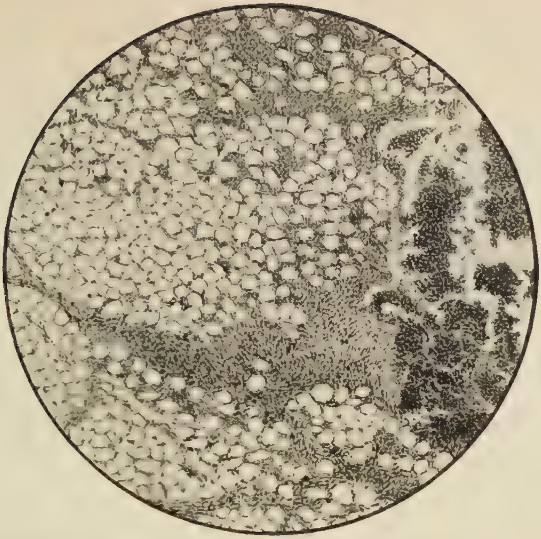

FIG. 14.—ABSCESS FORMATION IN THE SUBCUTANEOUS TISSUES IN THE EARLY STAGE (FOUR DAYS).

To the right of the illustration are seen masses of round cells (polymorphonuclear leucocytes), which are ready to break down into pus. To the left is seen fatty tissue, permeated by strands of fibrous connective tissue in a state of cell proliferation.

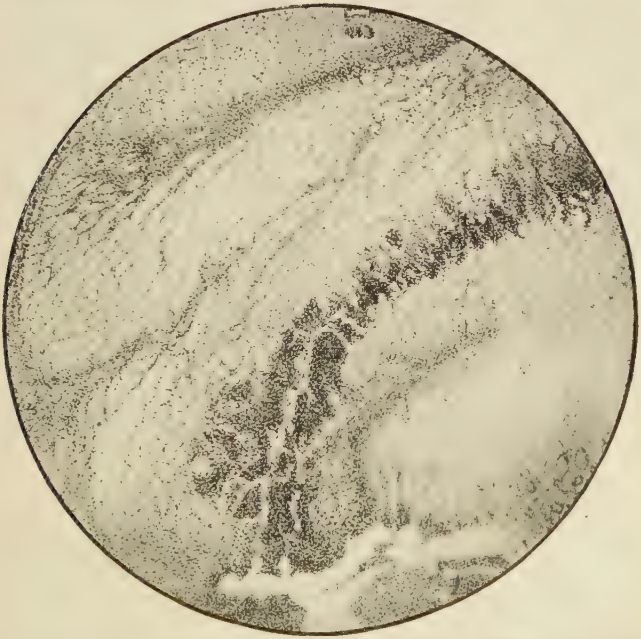

FIG. 15.—SECTION OF ABSCESS IN SUBCUTANEOUS TISSUES (SEVEN DAYS).

The structureless pus is seen below and to the right, and above it the intensely cellular lining of the abscess cavity, which is in reality infiltrated with bacteria. The tissues beyond are in a stage of proliferation similar to that seen in Fig. 14.

(For the loan of these illustrations we are indebted to Mr. G. Lenthal Cheatle.)

granulation tissue appears to secrete pus, and was formerly called a 'pyogenic membrane.' Its appearance was anxiously looked for by surgeons in the days when suppuration was considered essential for the healing of wounds, since it opposes a strong barrier to the bacteria and their toxins, and in large measure prevents their entering the blood-stream. Thus the formation of thick, creamy pus of a yellowish colour, such as is produced by such a pyogenic membrane, was looked upon as a sign that the patient was practically out of danger of 'blood-poisoning,' and the pus itself was termed 'laudable.'

Abscesses do not as a rule spread equally in all directions, since certain structures, especially bone and fascia, are more resistant than cellular tissue or fat. The process of extension continues along the line of least resistance until the abscess *points* at some surface, and finally bursts through the skin or into the alimentary canal or other cavity. When this happens, the bacteria and their toxins alike are able to escape, and in consequence their action on the pyogenic membrane is less profound, so that the contest between the defensive powers of the tissues and the destructive powers of the bacteria, in which the latter were victorious at first, turns in favour of the tissues. The bacteria which remain are attacked with greater effect by the leucocytes, and are gradually removed; the supply of toxin diminishes; the inflammatory process in the abscess wall becomes less severe, and finally organization of the granulation tissue commences. This begins at the bottom of the abscess cavity, the walls of the upper portions being kept apart from one another by the pus which is still secreted, though in gradually diminishing quantity. The result is that the abscess cavity fills up from the bottom, and finally heals altogether. This process is facilitated if efficient drainage is provided, so that the bacteria and toxins find a ready exit.

Occasionally the defensive powers of the body are sufficient to kill off the bacteria after pus has been formed, and before it has escaped. When this happens, the pus may become absorbed and the cavity obliterated, or the fluid part only may be removed, and the leucocytes (which undergo fatty degeneration) remain as a cheesy, structureless mass. In either case the abscess wall organizes into fibrous tissue, constituting a deep scar, in the centre of which may be the inspissated pus. It is rare, however, for this to happen, except in the abdomen, and then usually in connection with the appendix, Fallopian tube, or liver.

The **Clinical Signs** and **Symptoms** of an acute abscess may be arranged under three headings:

1. The *local signs* consist of a patch of inflamed tissue, indicated by heat, pain, redness, and swelling, which latter is at first hard and brawny, but when pus forms, the centre becomes soft and elastic, whilst superficial œdema is more marked, and the pain throbbing in character. Naturally, the amount of this pain depends entirely upon the density of the tissue affected and the supply of sensory nerves to

the part, suppuration beneath a resisting membrane, such as the palmar fascia, being always intensely painful. *Fluctuation* is the most characteristic sign of the presence of fluid; it is obtained by making firm pressure with the finger or fingers of one hand on one part of the swelling, whilst the fingers of the other hand placed on another part receive the impulse transmitted across the intervening space in the form of a fluid wave. Some soft solids give a sensation of fluctuation—*e.g.*, lipomata and soft, rapidly-growing sarcomata; whilst, on the contrary, it may be absent when the fluid is under great tension, or surrounded by a thick wall, or widely diffused in such a structure as the glandular tissue of the breast.

Sometimes, when the pus is small in quantity, all that can be detected is a feeling of elastic resistance in the centre of the brawny hyperæmic mass; but this, to the practised finger, is quite as conclusive of the presence of fluid as fluctuation. When the pus is placed deeply under muscular and fascial planes, very careful examination may be needed in order to determine its presence; the surgeon must not be misled by the sense of fluctuation obtained across the fibres of a muscle; none is noticed, however, by palpating along the course of its fibres. Marked and increasing œdema is frequently conclusive of the presence of deeply-seated pus—*e.g.*, in acute osteomyelitis, and suppurating mastitis.

If left to itself, an abscess sooner or later *points* and bursts. As it increases in size, it travels in the line of least resistance, and so may either find its way direct to the surface, or may burrow along muscular and fascial planes, or into adjacent cavities. The actual bursting of an abscess is often due to some injury—it may be a slight one —but is usually preceded by ulceration or necrosis of the integument.

2. *Pressure effects* are mainly due to the mechanical influence of the swelling upon surrounding structures. The most evident are those due to the irritation of nerves, as a result of which neuralgic pain may be present, or the patient may refer the pain to some distant unaffected region. In some cases, where large bloodvessels traverse the suppurating focus, the surrounding tissues may be destroyed, leaving them exposed in the abscess cavity as bands. Thrombosis and subsequent obliteration may result, especially in the veins; or occasionally hæmorrhage follows, due to sloughing of the arterial wall (suppurative periarteritis), preceded perhaps by an aneurismal dilatation of the vessel, owing to its loss of external support. Such effects occur both in acute and chronic abscesses.

3. The *general effects* of the formation of an acute abscess are those of increased fever, sometimes amounting to a rigor, and leucocytosis. A *rigor* consists of a definite series of phenomena, the result of the stimulation of the thermogenic centres by an accumulation of toxin in the blood. It is very similar in nature to an attack of ague, being ushered in by a feeling of intense cold and discomfort; the features are pinched, and the teeth chatter. The skin, however, feels dry

and hot, and the temperature of the body rapidly rises. The sensation of cold is partly due to the contact of air at a maintained normal temperature with the hot, dry, unperspiring skin, and also possibly to the condition of superficial anæmia which is present. After this stage has lasted a variable period, the patient gradually begins to feel warmer, the face becoming flushed, the thermometer ceasing to rise, and the skin commencing to act. Finally there is a rapid fall of temperature accompanied by profuse perspiration, which probably eliminates the toxin, but leaves the patient more or less exhausted. For *leucocytosis* and its value in the diagnosis of suppuration, see p. 62.

Pus and its Constituents.—Normal or, as it was formerly called, healthy or laudable pus is a thick, creamy fluid, having a specific gravity of about 1030, an alkaline reaction, no smell (unless putrefying or due to the activity of the *B. coli*), and containing 85 to 90 per cent. of water. If allowed to settle, it separates into two layers, an upper or fluid part, the liquor puris, which is usually clear or slightly opalescent, and a deposit of a yellowish-gray colour, which is usually more bulky than the fluid portion. The liquor puris is derived from the plasma exuded from the vessels. It may undergo coagulation after removal from the body, a very loose clot being formed. Frequently, however, this does not happen, perhaps because it has already coagulated within the abscess, and the resulting fibrinous network has been dissolved by the peptonizing ferment of the toxins, or destroyed by the leucocytes. It consists chemically of an albuminous fluid very similar to serum, but more dilute, and contains bacterial toxins, enzymes, proteoses formed by the digestion of proteids, etc. Sometimes (when the abscess involves a region containing fat) a few globules of oil float on the surface or occur in an emulsified form in the fluid.

The solid portion consists in the main of polynuclear leucocytes, most of which, as has been already pointed out, are dead and degenerated, whilst a few are still alive and capable of spontaneous movements. In addition, there are fragments of cells and nuclei from the tissues, shreds of fibrous tissue, granular débris, and bacteria. A few red blood corpuscles are often present.

When pus is mixed with blood, it is termed **sanious** (short for **sanguineous**); when thin and acrid, it is **ichorous; curdy,** when mixed with curdy shreds, as is more usually seen in chronic suppuration of a tuberculous nature. **Blue** or **green** pus is due to the activity of the *B. pyocyaneus;* the colour is often seen best on the outer layers of the dressing which are exposed to the air. Its occurrence is uncommon. **Muco-pus** is of a sticky, glairy character, and arises from inflammatory conditions of mucous membranes; **sero-pus** is thin and more liquid from admixture of serum, and is derived from serous membranes.

Occasionally an abscess contains not only pus, but also **gas.** This may be due to the existence of a direct communication with some hollow viscus—*e.g.*, the stomach or intestine—and hence is met with in many cases of subphrenic abscess. In some of the many types of abscess associated with appendicitis the gas is due to the activity of the *B. coli* either alone or mixed with other germs. In the limbs it is usually the result of infection with a gas-producing organism—*e.g.*, the *B. aerogenes capsulatus* or *B. œdematis maligni*, and is associated with an acute spreading cellulitis or gangrene.

Treatment of Acute Abscess.—When an inflamed area is threatening to suppurate, the formation of pus can be but rarely *prevented*. In the early stages, elevation and rest of the part, together with the application of evaporating lotions and the administration of quinine with iron, may sometimes succeed in accomplishing this, or Bier's treatment by induced hyperæmia may be useful.

In a few regions of the body, pus may be *absorbed* after its formation, but only when situated in a cavity of highly absorbing powers, such as the anterior chamber of the eye (hypopyon) or the peritoneal cavity. In the former the process of absorption may certainly be observed under the influence of local and general treatment.

As a rule, however, one relieves pain and encourages suppuration by applying fomentations (medicated with opium or belladonna) or poultices to the part, and then, as soon as pus is present, an incision is made to *evacuate* the abscess cavity. The opening must be large enough to prevent re-accumulation: it should be placed at a spot suitable for drainage, but as far as possible from sources of secondary contamination, and in such a direction that movements of the part do not close it. Where the opening is not dependent, it may be desirable to make a counter-opening by pushing the finger or a probe through the abscess wall amongst the tissues, making it protrude beneath the skin at some dependent spot, and cutting down upon it in this direction. In dealing with deep abscesses in dangerous regions, *Hilton's method* may be advantageously employed. This consists in dividing merely the skin and superficial structures, and then thrusting a pair of sinus or dressing forceps into the abscess cavity. On forcibly separating the blades a sufficient opening is made to insert the finger, and subsequently a drainage-tube. Rigid antiseptic precautions must be taken in opening abscesses, for, although bacteria are present, it is most essential that no fresh germs be admitted, thereby giving rise to a mixed infection, the presence of which is most unfavourable to rapid repair.

It is advisable to remove any sloughs that are present, and when the abscess has burrowed, or if the cavity is large, it should be gently explored with the finger, but adhesions or bands crossing it should not be indiscriminately broken down, as they may contain large bloodvessels. All that is subsequently needed, if there is no complication, such as the presence of dead or diseased bone, is to arrange for drainage, as by inserting a rubber or glass drainage-tube or a slip of protective, and to prevent a mixed infection by a carefully-applied antiseptic or aseptic dressing, or by packing the cavity with gauze soaked in an iodoform emulsion (10 per cent.). There is often a considerable loss of blood during the first twenty-four hours from the yielding of the capillaries in the abscess wall, owing to the sudden relief of tension; but this usually ceases of itself, or yields to moderate pressure. *When once the abscess has been evacuated, no more pus is formed if external contamination* (*mixed infection*) *has been avoided,* the discharge being merely serous, and the wound rapidly closing and healing, and this in spite of the fact that bacteria are for a while present; they are evidently unable to develop or do any harm as the result of a local immunity. An abscess cavity which has contained foul or stinking pus usually runs a healthy course if aseptic conditions are maintained, and if no communication with the bowel exists, the discharge becoming free from smell in a few days.

The persistent discharge of pus from an abscess which has been opened means either that the opening is too small, or that matter is pent up in an undrained loculus, or that a mixed infection has occurred, or occasionally that the vital powers of the patient are so deteriorated that it is difficult to establish healthy repair, or that the part is not kept at rest. Free drainage, the improvement of the general health, and keeping the affected part at rest are essential elements in the successful treatment of an abscess. A small opening must be enlarged; loculi must be drained, and, if need be, a counter-opening made. Debilitated patients may sometimes need to be sent to the seaside before healing will occur.

Chronic Abscess of Pyogenic Origin.

A chronic abscess may be defined as a collection of pus which forms slowly and without any signs of active inflammation, so that it is sometimes termed a *cold* or *congestive* abscess. The vast majority are tuberculous in origin, but a few may be due to the liquefaction of other granulomatous masses, to an infection with pyogenic bacteria of low vitality, or to chronic pyæmia. The clinical phenomena are alike in the two types, and will be dealt with later (p. 182), but there is one important distinction between them, in that the lining membrane of the pyogenic variety is merely granulation tissue more or less active, whilst in the tuberculous form it contains living tuberculous material. Hence, whilst a simple incision under aseptic precautions is all that is required in the former, the latter also needs removal of the tuberculous tissue by scraping or some such agency.

Sinus and Fistula.

When an abscess, acute or chronic, has been opened, and does not heal completely, a communication often persists between the original seat of the disease and the exterior, which is known as a sinus or fistula. A **Sinus** is a narrow track lined with granulations, penetrating into the tissues, open at one end and closed at the other; the discharge may be purulent or merely serous. A **Fistula** is an abnormal communication, congenital or acquired, between two cavities, or between a cavity and the external surface. When such conditions result from the non-closure of an abscess of pyogenic origin, the walls consist of an external fibro-cicatricial layer and an internal lining of more or less healthy granulation tissue. Should the abscess have been of tuberculous origin, the lining membrane will also contain tubercles. If the fistulous track is short, the granulating wall may become covered with epithelium, and under such circumstances the fistula cannot be expected to close naturally.

It is often a matter of difficulty to secure the healing of a sinus or fistula, and the following are the main *causes of their non-closure:* (1) The presence of some chronic irritant in the depths of the wound, such as a piece of the clothing, a catgut ligature, a piece of silk or silver-wire used in an operation, or of some diseased tissue, such as a fragment of dead or carious bone; (2) the irritation of discharges finding an exit through the abnormal opening, such as urine, fæces, or fœtid pus; (3) insufficient drainage of a deep cavity, so that there is always a certain amount of tension in the wound; (4) want of rest to the part, due either to voluntary movements, as in the limbs, or to involuntary muscular action in the immediate neighbourhood, as in fistula-in-ano; (5) tuberculous infection of the wall, or a tuberculous deposit at the bottom of the sinus; (6) the growth of epithelium down the sinus or round the margin of the fistula; or (7) constitutional debility.

The orifice of a sinus often looks depressed from the amount of infiltration around, but when the surrounding tissues are healthy, puckering in of the orifice is a good sign; in cases where foreign bodies are lodged within, or where diseased bone exists, it is usually surrounded by prominent fungating granulations.

Treatment.—The removal of the cause is the first thing to accomplish in dealing with a sinus or fistula. The passage must be dilated or slit up to allow of access to the deeper parts of the wound, to remove any foreign body which may be present, or to allow of the satisfactory drainage of a deep cavity. The making of a dependent counter-opening often suffices to cure a sinus. A thorough disinfection of the part by pure carbolic acid or chloride of zinc (40 grains to 1 ounce) must also be undertaken, and the wound dressed by packing with suitable material and kept at rest, whilst the general health of the patient is improved by tonics. Occasionally, the pressure of a roller bandage to immobilize the part is all that is required, or the application of a suitable splint. The most complete and certain method is to lay the sinus open and destroy the lining granulation tissue by scraping or cauterizing, and then to pack the wound, allowing it to heal from the bottom by granulation.

Should a fistula have become lined with epithelium, the edges will require paring, and some form of plastic operation must be undertaken to close the opening.

Sinuses often react well to vaccine treatment, and this is especially the case with those left after empyemata, when a single injection of

50,000,000 to 100,000,000 dead pneumococci will often prove efficacious. Tuberculous sinuses, such as may be left after an operation for glands in the neck, etc., are sometimes curable by the use of tuberculin (TR), but there is not much chance of success if the non-healing is due to dead bone, movement, etc.

Results of Long-continued Suppuration.

When an abscess, acute or chronic, pyogenic or tuberculous, is treated antiseptically, the formation of pus quickly ceases; the wound may not heal for months, but the discharge is merely serous, and no constitutional results will be manifested. The temperature remains normal, and the general health unimpaired, if no other disease is present. Should a tuberculous abscess become infected with pyococci, or a mixed infection occur in a pyococcal abscess, the discharge of pus continues or reappears, and fever to a varying degree follows. When an extensive or deep abscess is thus involved, the discharge may become very profuse, high fever may supervene, grave visceral changes may follow, and the patient may lose his life through toxæmia and exhaustion. *Long-continued suppuration is always an evidence of persistent infection,* and prominent amongst the conditions which arise therefrom may be mentioned hectic fever and lardaceous disease of the viscera.

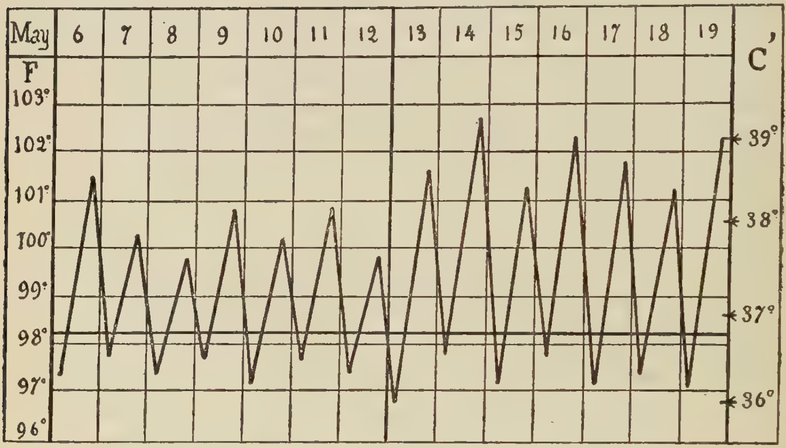

FIG. 16.—TEMPERATURE CHART OF HECTIC FEVER.

Hectic Fever may be defined as a chronic toxæmia due to the continued absorption of small doses of toxins, and is met with in any condition of chronic infection—*e.g.*, after acute or chronic suppurative affections of bones or joints, in tuberculous disease of the lungs, and in chronic syphilitic or cancerous ulceration. It is characterized by a diurnal elevation of temperature (Fig. 16) during the afternoon or evening, when the face becomes flushed (*hectic flush* of the cheeks), the eyes are bright and sparkling, the pupils dilated, and the patient feels better and stronger. The pulse, however, is small, compressible, and ten or twenty beats quicker than it should be. This condition continues till late in the night, by which time the temperature may have risen four or five degrees. In the early morning it falls as rapidly as it had formerly risen, and usually drops to the normal, or even below it, and this is accompanied by a profuse perspiration, which leaves the patient in a much-exhausted condition. Day by day this continues, the fever and sweating together causing rapid and marked emaciation.

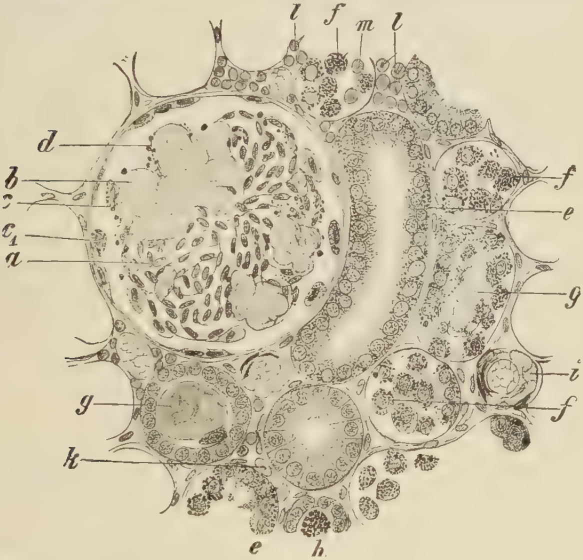

FIG. 17.—AMYLOID KIDNEY IN EARLY STAGE. (ZIEGLER.)

Treated with Müller's fluid and perosmic acid. × 300.) *a*, Normal capillary loop; *b*, amyloid capillary loop; *c*, fatty epithelium of glomerulus; c_1, fatty epithelium of capsule; *d*, oil-drops on the capillary wall; *e*, fatty epithelial cells *in situ*; *f*, loosened fatty epithelial cells; *g*, hyaline coagula (forming 'casts'); *h*, fatty cast in section; *i*, amyloid artery; *k*, amyloid capillary; *l*, infiltration of connective tissue with leucocytes; *m*, round cells (leucocytes) within a uriniferous tubule.

Amyloid, Albuminoid, or **Lardaceous Disease** of various organs is a condition due to the deleterious effects of toxic compounds circulating in the blood, whereby the walls of the smaller arteries (Fig. 17, *b* and *i*), and subsequently the protoplasm of certain viscera, are converted into or infiltrated with a waxy substance, from which lardacein, an extremely insoluble proteid body, may be obtained. The name 'amyloid' is an entire misnomer, as this material is in no way akin to starch. It occurs as a waxy homogeneous material, becoming a dirty brown on the application of tincture of iodine, and an inky blue when sulphuric acid is subsequently added. With methyl-violet the amyloid substance is coloured ruby-red, whilst normal tissues are stained blue or indigo. The organs mainly affected are the liver, spleen, kidneys, and villi of the intestines. The *liver* becomes evenly enlarged to a considerable degree, often reaching from the fifth rib to the umbilicus, or lower; it is firm in consistency, like indiarubber, painless, and waxy-looking on section. The arterioles and capillaries in the intermediate zone of the lobules are those first affected, but the gland cells soon participate in the change. The glycogenic and bile-producing functions are naturally interfered with, so that the digestive process, and especially the power of absorbing fats, is impeded, although the appetite may remain good. The *kidneys* become similarly enlarged, the change commencing in the arterioles leading to the glomeruli (Fig. 17), but the capillaries and the tubal epithelium are also early affected. In this stage the urine is very abundant (from the increased filtration through the degenerated walls), pale, limpid, and containing a few hyaline casts and fatty cells; later on, when the tubules are more largely involved, there is less urine, with a higher specific gravity, and a considerable amount of albumen. The *spleen* increases in size, but not always to so great an extent as the other viscera; the Malpighian bodies are the chief seat of the mischief. The capillaries in the *villi of the intestines* become lardaceous, and allow of an increased transudation of the fluid parts of the blood, resulting in diarrhœa; the absorption of nutriment is thereby much lessened, and thus both by increased excretion and diminished absorption of food the strength of the patient is steadily undermined.

Amyloid changes in the viscera, far from being a contra-indication to operation, are rather to be considered as a sign that radical treatment is urgently necessary, unless the general condition of a patient is such that he cannot stand the strain of it. If by an operation—*e.g.*, excision or amputation—the local disease can be eradicated, the amyloid changes in the viscera may totally disappear. At the same time one must not forget that the kidneys are seriously damaged, and that antiseptics, such as carbolic acid, which are absorbed into the blood and eliminated in the urine, may light up an acute nephritis with possibly fatal results.

Persistent suppuration is present in a large series of other conditions than those following the opening of an abscess, prominent amongst them being that known as **oral sepsis.** The lesion usually present is pyorrhœa alveolaris (*q.v.*), in which suppurating pouches form in the gums around the roots of teeth, which are generally dirty, decayed, and covered with tartar; the tongue is coated, and the breath offensive. Grave results may follow, partly from the constant swallowing of bacteria and their toxins, partly by their direct absorption through the granulation tissue which surrounds the teeth. (1) The ingestion of pyogenic bacteria and their toxins acts injuriously upon the gastric and intestinal mucous membranes, so that the natural antiseptic powers of the gastric juice are lost or diminished; and thus a chronic gastritis may ensue, as also gastric or duodenal ulcers, whilst it is a noticeable fact that a septic state of the mouth due to bad teeth is constantly found in the subjects of appendicitis. In this connection it is advisable to note that careful disinfection of the buccal cavity should always follow, as well as precede, such operations as gastro-enterostomy, excision of the tongue, removal of the jaw, etc., so as to minimize the risks of infection which might follow. (2) The air-passages may become infected as an outcome of oral sepsis, in the form of a tracheitis with an abundant muco-purulent expectoration. Aspiration pneumonia may follow the administration of an anæsthetic in such cases. (3) A mild anæmia of a secondary type may develop, characterized by a blood count showing 3,000,000 or so red corpuscles, 60 to 70 per cent. of hæmoglobin, and a moderate leucocytosis. Occasionally the anæmia may be of a graver type, corresponding to the pernicious variety (Hunter). It is also interesting to note that in lymphatic leukæmia ulceration of the mouth is often present. (4) Many other general conditions may ensue—*e.g.*, a constant feeling of malaise, headache, mild furunculosis, and various phenomena due to neuritis. Occasionally severe pyrexia of a typhoid type has supervened, the temperature falling rapidly, and the patient recovering as soon as the mouth and teeth had received attention. Chronic osteitis and arthritis also occur, and the condition described hereafter as chronic osteo-arthropathy is due to the chronic absorption of toxic material.

II. **Cellulitis.**

Cellulitis (or, as it used to be termed, *diffuse phlegmon*) is a disease characterized by the existence of a spreading inflammation of the subcutaneous or cellular tissues, due to the activity of pyogenic organisms, and running on to suppuration, sloughing, or even to extensive gangrene.

Causation.—The one essential is the infection of the cellular tissues with organisms which have gained an entrance through an operation wound, or through an accidental breach of surface, or even through some slight graze, prick, or scratch. Deep infected wounds which are not properly drained are amongst the most favourable for the development of this condition, especially if the general health of the individual is bad, if he is suffering from albuminuria or diabetes, or if his surroundings are of an insanitary nature. Wherever much loose cellular tissue is present, inflammatory phenomena readily supervene, owing to the absorption of bacteria from neighbouring contaminated structures—*e.g.*, pelvic cellulitis arising from an infected uterus, or cellulitis of the neck from an ulcerated throat.

Bacteriology.—The *Streptococcus pyogenes* is the organism most frequently found in cases of cellulitis, particularly when there is much tendency to spread. In some of the more localized forms the *Staphylococcus pyogenes* is present, whilst in the gravest and most acute manifestation the *B. œdematis maligni* is responsible for the trouble (p. 122), and the disease is then identical with what is usually known as acute emphysematous or infective gangrene.

Clinical History.—The symptoms necessarily differ somewhat according to the site of inoculation and the virulence of the causative microbes, and hence anything from a localized suppuration to the acutest form of spreading gangrene may result. In a case of moderate severity, due to a prick or abrasion which has become infected, there is often a period of quiescence for a day or two, and the site of inoculation shows but slight signs of inflammation, beyond being a little tender. The patient, though feeling somewhat seedy, is able to continue his work, but is finally obliged to give up, owing partly to the increased pain, partly to his general condition. Fever is almost always present to a greater or less degree, and in the more severe types one or more rigors occur, or the temperature may be subnormal, owing to the intensity of the toxæmia. The affected part is found to be hot, tender, and infiltrated; if superficial, it looks red and angry, and feels brawny. In some cases local hæmorrhages or petechial spots are found in addition to the other inflammatory phenomena. The course of the case depends to a very large extent upon the treatment adopted; if freely incised, the process may become limited, and although suppuration and sloughing occur, repair is readily effected; if, however, the virus is very active, or the patient's power of resistance low, or if the inflamed area is left to itself or merely poulticed, the process may spread rapidly, and extensive destruction follow. Intense pain and sleeplessness, accompanied perhaps with delirium, form the most prominent symptoms, and these, together with the toxic fever, rapidly exhaust the patient's strength. Suppuration at length occurs, but is often of slow development, and the swelling may remain hard and brawny for some time in such a region as the neck with no evidence of softening, so that it may be difficult to determine whether pus is present or not. The infiltrated cellular tissues are likely to slough, and in a limb extensive subcutaneous necrosis may occur, although the skin only gives way in places; hence it is often possible to pass a probe between the skin and the deep fascia over a considerable area. Sometimes the inflammation skips a part of the limb, the chief focus of mischief being found at a distance from the original site of inoculation, whilst the intervening portion is but little affected, or shows the characteristic features of acute lymphangitis (*q.v.*). This is due to the organisms or their toxins being transmitted along the lymphatics, and then arrested at a higher level. Occasionally the trouble spreads along the deeper areolar planes, or even along muscular bellies, which may be infiltrated with pus or may actually slough. In all these more severe forms the patient runs a considerable risk of developing general septicæmia or pyæmia.

Treatment.—Careful attention to the dicta of antiseptic surgery can prevent the occurrence of cellulitis to a very large extent in casualty and operative work. Abrasions and small punctured wounds should always be protected, and all penetrating injuries disinfected, especially if the patient runs exceptional risk of infection owing to his occupation or surroundings, or to the nature of the injury. Should inflammatory phenomena supervene, the application of antiseptic fomentations, such as the boracic poultice, may prevent their extension, whilst the bowels should be freely acted upon and the general health attended to. If suppuration is present or is threatening, free incisions in the long axis of the limb should be made into the brawny tissues, so as to give exit to the serous and irritating discharges, and to allow sloughs to be cut or scraped away; the wounds thus made are lightly packed with aseptic or iodoform gauze, over which the usual dressings are applied. The object of this is to drain the fluids from the parts by capillary action, and hence an effective junction must be maintained between the gauze drain and the surrounding dressing. It is often wise to incorporate a piece of sterilized gutta-percha tissue or mackintosh in the outer folds of the dressing, so as to keep the parts moist and encourage a free discharge. Extension of the mischief requires further incisions, and the surgeon must follow up the disease with the knife. At the same time the patient's health and strength must be maintained by the administration of suitable food, drugs, such as quinine, and stimulants.

After the bleeding caused by the incisions has ceased, the limb should be daily immersed in a warm bath for some hours so as to dilute the toxins and render them innocuous. The bath should not continue for more than three or four hours at a time, for fear of the tissues becoming sodden. Sterilized salt solution at a temperature of 105° to 110° F. does perfectly well; antiseptics are practically useless in checking the disease when once started; the surgeon has to depend mainly on relief of tension, the removal of toxic discharges, and the antiseptic power of the tissues. At the same time the utmost care must be taken to prevent any fresh or mixed infection of wounds from decomposition of discharges.

Polyvalent antistreptococcic serum (p. 27) has also been employed as a curative agent, with a view to destroy the streptococci (probably by a bacteriolytic action) and immunize the system to their further development. A dose of 20 c.c. (1 c.c. = ♏xvii.) may be given to start with, followed by 10 c.c. twice a day beneath the skin of the back or abdominal wall. The results have been very variable; sometimes it is apparently effective, but not unfrequently the results have been most disappointing. In the less acute cases vaccine treatment may be beneficial.

Special Varieties of Cellulitis.

Cellulitis of the Axilla not unfrequently follows an infected wound of the hand, such as occurs in the post-mortem room, and hence is not uncommon in medical practitioners, students or nurses. It may also be caused by extension from an axillary lymphadenitis. The tissues of the armpit become hard and brawny, the pain is severe, especially on movement of the shoulder, and the disease is liable to spread towards the chest walls under or between the pectoral muscles; it may also travel upwards, and lay open the shoulder-joint from sloughing of the capsule, and so give rise to an acute arthritis. Early and extensive incisions are required in order to prevent such complications, but respect must be paid to important vessels and nerves contained in the cavity

Cellulitis of the Scalp usually results from a wound which has traversed the occipito-frontalis aponeurosis, and opened up the subjacent layer of loose areolar tissue; it may, however, follow a simple laceration of the scalp and remain superficial. In the latter case the scalp becomes red, œdematous, and tender, but the inflammation remains more or less localized; in the former, pus forms beneath the aponeurosis, and extends to its limits of attachment, so that abscesses are likely to point in the forehead just above the eyebrows, over the zygoma, or along the superior curved line of the occipital bone. The whole scalp may be lifted up, and the patient runs a risk of necrosis of the cranial bones and of various intracranial complications. The scalp itself, however, rarely sloughs owing to its abundant vascular supply. In both conditions the temperature is often high and the patient severely ill. The *treatment* consists in making early and free incisions parallel to the lines of the vessels, and the insertion of drainage-tubes when the pus is beneath the aponeurosis.

Cellulitis of the Orbit is not an uncommon sequela of penetrating wounds in this region, owing to the difficulty of rendering them aseptic and of draining them. It may also result from inflammation of the bony walls, secondary to suppuration within the cranial sinuses. The orbital tissues become infiltrated and swollen, the lids are œdematous, and the eyeball is thrust forwards (proptosis). The inflammation may spread to the meninges, owing to the dura mater being continuous with the orbital periosteum through the foramina by which the nerves and vessels enter. Necrosis of the orbital walls may also occur, whilst the eye itself may suffer either from an infective panophthalmitis due to lymphatic infection, or from optic neuritis secondary to retro-ocular inflammation and pressure, or at a later date from optic nerve atrophy secondary to cicatricial contraction around the nerve. If the cellular tissue of the orbit sloughs, the subsequent movements of the globe may be much hampered, or indeed lost, whilst the lids may be drawn back to such an extent as to prevent their complete closure.

Treatment.—No penetrating wound of the orbit ought to be closed if there is any question of its infection; indeed, it is often wise to increase its size slightly, so as to enable the deeper parts to be explored and drained. If cellulitis follows, the original wound must be opened up, and possibly fresh incisions made either through the lids or through the fornix conjunctivæ. Antiseptic fomentations are then applied. If panophthalmitis supervenes, the eyeball must be incised crucially; this is a safer proceeding than enucleation, which is more liable to be followed by meningitis.

Cellulitis of the Neck is usually secondary to lesions in the throat, and therefore associated with follicular tonsillitis, diphtheria, or scarlatina, the process probably starting in a deep lymphatic gland; it occasionally follows operations on the neck. The tissues beneath the deep cervical fascia become infected, usually with streptococci, and sooner or later suppuration occurs. The affected side of the neck is swollen, red, and brawny; severe pain of a deep tensive character is experienced, and this is increased by movements of the head or jaw. The swelling is often peculiarly hard and resistant (the *woody* angina of French writers), and although œdema may be present, it may be several days before the surgeon can detect any focus of softening suggestive of suppuration. During this period the constitutional symptoms are severe; fever may be high, and the pain and subsequent sleeplessness may exhaust the patient, whilst the difficulty of swallowing hinders his nutrition. Dangerous symptoms arise from pressure on important vessels and nerves, from extension of the inflammation to the mediastinum or to the glottis, causing œdema and consequent dyspnœa, or from the supervention of pyæmia owing to venous thrombosis. The process usually ends in sloughing of the cellular tissue and suppuration, the pus burrowing widely if a free exit by incisions through the deep fascia is not provided.

Treatment.—The causative lesion in the throat must be attended to, any operation wound freely opened up and drained, and the general condition improved by the administration of nourishing fluid food, stimulants, and quinine. Antistreptococcic serum may also be injected, but sometimes antidiphtheritic serum (given hypodermically or by mouth) has been found more useful. Locally, fomentations are applied in the first place; but on the onset of suppuration, or before, if the pressure symptoms are severe, or if the affection is obviously extending, free incisions must be made along lines of safety beneath the deep fascia, so as to relieve tension and give exit to discharges. It must be remembered that the tissues are matted together in such a way as renders their recognition difficult; and inasmuch as the pus often lies deeply, the greatest caution has to be taken to avoid injury of important structures.

Special interest has been directed to a form of this affection which occurs in the *submaxillary* region, and is known as *Ludwig's angina*. It is usually secondary to some buccal focus, or may occasionally result from the extension of inflammation beyond the capsule of lymphatic glands, or may originate in disease of the middle ear, the mischief spreading down along the posterior belly of the digastric. The swelling in these cases extends forwards beneath the chin, and may involve the floor of the mouth and base of the tongue, pushing that organ forwards, and even making it protrude from the mouth. Œdema of the glottis may supervene, or a sublingual abscess form. Treatment is similar to that indicated above, and one or more incisions may be required. Œdema of the glottis will probably require tracheotomy.

Pelvic Cellulitis is an infective inflammation of the loose cellular tissue which ensheaths the pelvic viscera. It may result from any penetrating wound, accidental or operative, which encroaches on this region—*e.g.*, extraperitoneal rupture or perforation of the bladder, suprapubic or lateral lithotomy, injudicious catheterism, curetting the uterus, and sometimes attempts to induce abortion. It may also be due to the absorption of bacteria from any of the pelvic viscera—*e.g.*, the bladder, prostate, rectum, uterus, or Fallopian tube. It is associated with all the local and general signs of deep inflammation, and often, indeed, with peritonitis, giving rise to a tense, firm, painful swelling, to be felt *per rectum* or *per vaginam*, and sometimes to an indurated mass of inflammatory effusion, dull on percussion, above the pubic arch. Abscesses may form, bursting either externally above Poupart's ligament or into some of the viscera, or possibly in both directions, producing intractable forms of urinary or fæcal fistulæ, whilst venous obstruction and pyæmia are likely to develop.

The surgeon may be called on to deal with such cases either in the early presuppurative stage, when rest, limitation of diet, small doses of opium, and fomentations to the hypogastrium, conjoined perhaps with hot antiseptic rectal or vaginal douches, should be adopted; or at a later date, when pus has formed and the abscesses need to be opened. An incision is generally made just above Poupart's ligament and close to the pubic spine; the abdominal muscles are divided to a sufficient extent to enable the surgeon to work downwards between the transversalis fascia and the peritoneum, which must be pushed aside in order to reach the broad ligament, where pus is frequently found. As soon as the subperitoneal tissue is opened, the knife should be discarded, and only blunt instruments or the fingers employed. The cavity of the abscess should be well washed out and efficiently drained, and possibly a counter-opening through the vagina may be required.

Intestinal obstruction may develop as a remote sequela from the contraction of cicatrices, and hydronephrosis may arise in the same way from pressure on the ureter.

III. Wound Infection.

When a wound, whether accidental or operative, has become infected with micro-organisms, healthy reparative action ceases, and is replaced by an inflammatory process of a suppurative type with the object of coping with the bacteria. To this condition the term *sepsis* was formerly applied, but with our modern knowledge the terms 'sepsis' and 'septic' are rarely needed, and, indeed, are better avoided where possible. The organisms usually present are staphylococci, but in the worst cases streptococci may be found, and in others the presence of saprophytic germs may constitute a mixed infection.

In casualty work wound infection is often unavoidable, and due to the dirty state of the skin or the nature of the accident; and, however thorough the subsequent disinfection, it may be impossible to render the parts sterile. After an operation, wound infection is usually due to some gross avoidable mistake or oversight, rarely to auto-infection. Ineffective sterilization of silk or catgut is perhaps the most frequent cause of infection, since the introduction of rubber gloves has safeguarded the hands of the surgeon and his assistants.

The **local** trouble may manifest itself merely as an acute or subacute suppurative process within the wound, or as an active cellulitis spreading into the adjacent tissues. It may commence deeply around a buried stitch, or more superficially. In the latter case the lips of the wound look red and puffy, the tissues often swell up between the stitches, which look as if they were too tight, and on introducing a probe pus may escape; the patient complains of pain, usually of a throbbing nature, and there is some rise of temperature, and in bad cases even a rigor. In the milder forms the trouble is limited to the immediate neighbourhood of the wound; but if neglected, or in an unhealthy subject, or if due to virulent germs, the phenomena of an acute cellulitis may supervene.

When the process starts in the deeper parts of the wound, nothing may be obvious on the surface for a few days, except perhaps some fulness and tenderness on pressure. It will usually be found, however, that the temperature is slightly raised, and that some tensive pain is present. Sooner or later an abscess develops and comes to the surface, and a sinus is likely to be left until the ligature or buried stitch has been absorbed or removed. The same holds good as regards silver wire, screws, plates, etc., which must be removed before healing can take place.

The **Local Treatment** of an infected wound consists essentially in the relief of all tension, and the application of warmth and moisture to the part, to encourage the local reparative activity of the tissues. Stitches must be immediately removed, and the wound widely opened up, so as to give a free exit to the pus. Undue interference with the wound, as by squeezing, scraping, etc., is to be deprecated, as thereby germs may be disseminated. Sloughs are left to separate by natural processes, and even syringing or washing out the wound must be limited in the early stages. Peroxide of hydrogen (10-volume solution) is useful, but not at first, since the sudden liberation of oxygen may drive germs into the tissues, and thereby increase the trouble. The application of stronger antiseptics is equally futile, since the germs are in the tissues, and cannot be destroyed without also involving these structures; moreover, the phagocytic power of the leucocytes is checked by such applications. The wound, thus opened up, is lightly but thoroughly packed with gauze, and if there is a deep cavity it may be desirable to introduce a drainage-tube, since pus does not easily escape along a gauze drainage-wick. Warm moist dressings, such as an antiseptic fomentation, are then applied, or the limb is immersed in a bath at a temperature of 105° to 110° F. for some hours daily. At the same time the bowels must be freely opened, and the general health of the patient carefully watched. In a few days, when granulations have formed, the wound may be irrigated with salt solution or swabbed out with peroxide of hydrogen. Healing is finally brought about by granulation, but can sometimes be hastened by strapping the edges of the wound together, or by grafting.

The general phenomena connected with wound infection vary chiefly in respect of the dose of toxins absorbed.

1. **Acute Toxæmia** (formerly known as **septic traumatic fever**) results from the absorption of a large dose of toxic material from some focus of infective inflammation of sufficient extent and virulence. A small collection of pus under pressure is capable of giving rise to marked toxic symptoms, whilst in spreading inflammations, such as erysipelas and cellulitis, the manifestations are often of a grave type. The same is true of infective inflammation of the peritoneal cavity, especially when the upper half is involved, since the communication with the lymphatics of the diaphragm is very free. Toxæmia is not unfrequently associated with a true septicæmia, and clinically it may be almost impossible to distinguish between the two.

The **Symptoms** are characterized by fever, except in some of the gravest cases, when the temperature may be subnormal, although the pulse may still remain high. This is accompanied by loss of appetite, a dry tongue, a quick pulse, rapidly becoming weak, severe headache, and nocturnal delirium of some intensity. The patient is at first constipated, but vomiting and diarrhœa may ensue from gastro-intestinal irritation, followed by fatal exhaustion and collapse; or he may become comatose and unconscious for some time before death, according to whether the toxins act principally upon the alimentary or nervous systems. Dyspnœa from pulmonary congestion, and albuminuria, also occur. Effective treatment of the cause, as by opening an abscess, or drainage, may lead to a speedy disappearance of the symptoms, but in spreading inflammation the toxæmia may not subside for some time.

Post-mortem Appearances.—Decomposition is early, rigor mortis feeble, and cadaveric lividity well marked, especially along the lines of the superficial veins and posteriorly. The blood coagulates imperfectly, and is dark and tarry in colour; if allowed to stand, the serum which separates from the corpuscles is much stained from the breaking up of the red blood cells which occurs in all acute infective cases. This condition explains the amount of cadaveric lividity, and also the post-mortem staining of the endocardium and tunica intima of the larger vessels, which is such a marked feature in these cases, and which was formerly supposed to result from a diffuse arteritis. Most of the serous cavities contain a certain amount of blood-stained fluid, and under almost all the serous membranes are well-marked petechiæ, especially under the pericardium and pleura. The lungs are deeply congested, particularly at the back, and very œdematous ; the liver, spleen, and kidneys are enlarged, pulpy, soft, and congested, notably the spleen. The epithelium of most of the secreting glands, if examined microscopically, gives evidence of cloudy swelling.

The **Treatment** of acute toxæmia must be chiefly directed to the local cause, which is dealt with by suitable surgical means. General treatment is merely symptomatic. Possibly a good purge may be advisable in the early stages, but in the later a supporting and stimulating plan of treatment must be adopted. Recently the acute toxæmia of peritonitis and similar conditions has been treated by the continuous injection into the rectum of large quantities of saline solution (ʒi. ad Oi.), and excellent results have been obtained; the injections are followed by diuresis and diaphoresis, which presumably assist in the elimination of the poison. In some cases intravenous injections may appear desirable, and then it is wise to insert the needle of the infusion apparatus directly into a vein without dissection, as the wound might otherwise become infected.

2. When the dose of toxins is smaller, but absorbed regularly and for a long time, a definite diurnal range of temperature follows, known as **hectic fever** (p. 82).

3. **Acute Sapræmia** is a term that is now rarely employed in surgical practice, but is rather retained for a condition which occurs during the puerperium, due to the decomposition of a portion of retained placenta, as the result of a mixed infection. The symptoms are moderately severe, and entirely due to chemical poisoning. Removal of the putrid mass results in almost immediate cessation of the fever and all the other manifestations.

IV. Septicæmia.

Septicæmia is an acute general infective disorder, arising from the development of some variety of pyogenic organism in the blood. It differs from pyæmia in the absence of secondary abscesses (although, as explained later, it may be associated with it), and from toxæmia or sapræmia, by the fact that the latter are merely due to the absorption into the blood of toxins generated in a diseased focus in which the bacteria themselves remain localized. In septicæmia the organisms circulate in the blood, though in many cases in but scanty numbers, so that it is necessary to take rather large quantities of blood (5 c.c. or more) for a bacteriological examination. Further, even in severe cases of septicæmia periods occur in which no bacteria can be detected in the blood, so that too much weight should not be attached to a single negative result.

Bacteriology. — The commonest organism is undoubtedly the *Streptococcus pyogenes*, which is found in about 50 per cent. of all cases; it is almost always present in the septicæmia dependent on puerperal diseases and in ulcerative endocarditis, where the lesion in the heart acts as the source of the bacteria in the circulating blood. Next in frequency is the *Pneumococcus*, which often causes septicæmia, even when no pulmonary or other local lesion can be traced. The *Staphylococcus pyogenes* is also a fairly common organism in this disease, and the prognosis is then decidedly better than in cases due to the streptococcus or pneumococcus.

Rare causes are the *B. coli* and allied organisms, *B. pyocyaneus*, *B. œdematis maligni*, and the *Gonococcus*.

Clinical History.—Septicæmia occurs most commonly from direct inoculation with suitable organisms through small lesions, such as post-mortem wounds, or from scratches or punctures with infected pins or instruments; it also in rarer cases follows operation wounds and severe lacerated injuries. It is the usual accompaniment of acute spreading gangrene (p. 122), and may be met with in cellulitis and cancrum oris (p. 123). As a rule the individual attacked is in a depressed and debilitated condition, perhaps deteriorated by alcoholic or other excesses, so that the inherent germicidal activity of the tissues is markedly insufficient to cope with the inroads of the disease.

The point of inoculation may be the seat of any of the forms of **local** trouble which we have already described under the title of cellulitis, and this may vary from a slight inflammatory blush to the acutest form of spreading gangrene.

The **General Symptoms** are those of fever, often ushered in by a distinct and severe rigor; the temperature reaches 104° or 105° F., and usually remains high, with but slight remissions and no intermissions (Fig. 18). Malaise is present, with loss of appetite, and the tongue is brown and parched. The pulse is quick and feeble, the heart-sounds are weak, and the heart itself dilated. The skin has often a slight icteric tinge, and petechiæ are present. Diarrhœa usually ensues, and may be blood-stained, whilst the urine is albuminous and contains blood. The patient, after a period of delirium, becomes comatose, and dies. Dyspnœa sometimes precedes the fatal issue, whilst the temperature may be exceedingly high, or occasionally subnormal ; the association of a low temperature with a very rapid pulse is always of grave import. Leucocytosis is usually present and well marked in the earlier stages, but is absent in the worst cases and towards the fatal issue ; even under these circumstances there is a *relative* increase in the number of polynuclears.

Occasionally a case takes a more favourable course when the local focus of trouble has been effectively dealt with, and perhaps suitable vaccine treatment adopted. The temperature falls gradually, and the patient slowly though surely regains his health. The accompanying temperature chart represents such a case, where the true septicæmia, as demonstrated by a blood examination, gradually disappeared after the uterus had been effectively curetted and disinfected (Fig. 18).

The **Post-mortem Signs** are those found in all cases of acute toxæmia, described above (p. 91), with the addition that on microscopical examination bacteria can sometimes be demonstrated in the blood and internal organs, especially the spleen.

The **Diagnosis** has to be made from the more virulent forms of the *acute exanthemata,* in which the patient is destroyed before the characteristic appearances are manifested; in such cases a definite opinion as to the nature of the affection is often impossible, if there is no clue as to the origin of the infection. *Acute toxæmia* is always associated with some very obvious focus of wound infection, but may be so severe as to cause grave anxiety for a time as to whether or not septicæmia is present. If, however, the wound is freely opened up and drained, the rapid disappearance of the fever proves that the mischief was merely a local, and not the more serious general, affection. A blood examination by cultural methods may assist in clearing up the diagnosis. From *pyæmia* it is known by the absence of repeated rigors and secondary abscesses.

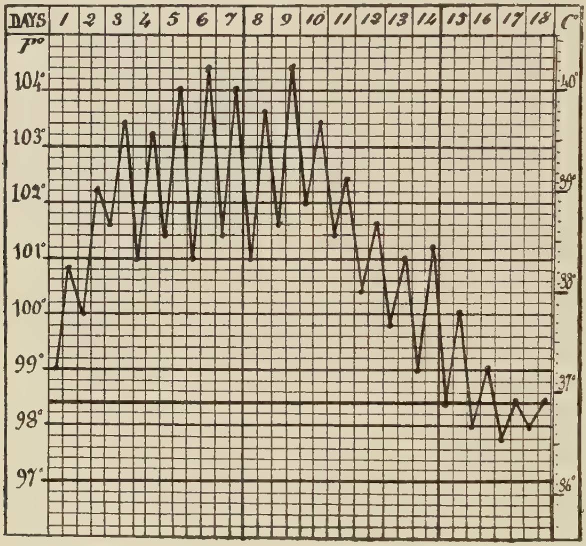

FIG. 18.—TEMPERATURE CHART OF A CASE OF PUERPERAL SEPTICÆMIA.

The **Prognosis** of acute septicæmia is always very grave, but it is to be hoped that the modern plans of treatment mentioned below may prove beneficial in diminishing the mortality.

The **Treatment** consists in dealing actively with any local focus of inflammation, either by free incisions, purification, and drainage, or by amputation ; but, unfortunately, this is seldom likely to be successful, as blood infection has probably already occurred. In addition to such means, tonics and stimulants, with plenty of suitable nourishment, must be administered. Antistreptococcic serum (p. 27) may be utilized when the streptococcus is responsible for the trouble, and cases have been reported as cured by its agency. Another plan which has been adopted is the intravenous injection of considerable quantities of normal saline solution, repeated two or three times a day; by this means diuresis and diarrhœa are induced, and it is hoped that thereby the organisms and their products may be eliminated. This treatment will probably be of greater value in cases of toxæmia than in those of true infective septicæmia.

A few cases have been successfully treated by means of autogenous vaccines, and if time permit (the preparation of the vaccine takes three or four days) this method should be tried. In the interval a stock vaccine prepared from similar, but exogenous, organisms may be employed. It is, however, not likely to be of much value in the acute and rapidly fatal cases, for which the serum treatment is still the best method at our disposal.

A more **chronic** variety of **septicæmia** is also recognised, which may last for weeks or months. The history usually commences with some localized inflammatory trouble from which the patient has never properly recovered. The temperature becomes of the hectic type, running up 3 or 4 degrees every night, and the fever is associated with profuse nocturnal sweats. Bacteria may be demonstrated in the blood at times. The probable cause of the trouble is the persistent absorption of germs into the blood-stream from some localized source of suppuration—*e.g.*, a hepatic abscess or a suppurating gall-bladder or appendix, or even a neglected pyorrhœa alveolaris; in other cases infective endocarditis is the cause of the trouble. The patient's health and strength are gradually lost, and, unless the local focus can be reached and dealt with, death is likely to result. Surgical interference, though dangerous in these debilitated patients, may be essential in order to attack the cause of the mischief. Apart from this, vaccine treatment must be relied on, together with such general measures as shall build up the general health and improve the resistance of the blood and tissues.

V. Pyæmia.

Pyæmia (Greek πυον, pus, and αιμα, blood) is a disease characterized by fever of an intermittent type, associated with the formation of multiple abscesses in different parts of the body, arising from the diffusion of pyogenic materials from some spot of local infection.

Bacteriology.—Any pyogenic organism may cause pyæmia, and, *theoretically*, pyæmia may arise as a complication following any acute abscess. As a rule, however, there is a sufficiently rapid development of granulation tissue to limit the spread of infection. The organism most commonly found is the *Streptococcus pyogenes*, but in a few cases the *Staphylococcus pyogenes aureus* has been observed, and less commonly the *Pneumococcus*, *Gonococcus*, or *B. typhosus*. The mere injection of cocci into the circulation is not sufficient to give rise to pyæmia; if they are few in number, a transient pyrexia may supervene, and then the germicidal powers latent in the blood destroy them; but if the dose is large, or the individual is not in a very resistant condition, septicæmia, and not pyæmia, results, unless special conditions are present which determine the formation of embolic abscesses. If the cocci to be injected are mixed with such a material or aggregated into such masses that the organisms are carried on particles too large to pass through the terminal arterioles and capillaries, abscesses develop wherever they lodge. In human pathology the infective emboli consist of zooglœa masses of organisms, or of infected particles of disintegrating blood-clot (Fig. 19).

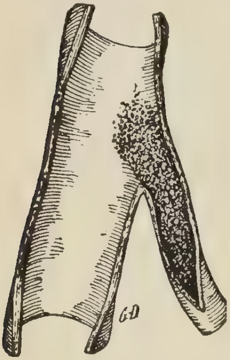

FIG. 19.—DISINTEGRATING CLOT LYING IN A VEIN IN A CASE OF PYÆMIA. (AFTER TILLMANNS.)

The apex of the clot projects into a larger trunk, in which circulating blood is present, and from it infected emboli would be detached.

The **Cause** of pyæmia may be stated to be any condition which leads to the formation and detachment of infective emboli in the circulation, such conditions occurring mainly in the veins from disintegration of a thrombus (*infective phlebitis*), but occasionally in the heart (*infective endocarditis*). Acute infective inflammation of the cancellous tissue of bones is very commonly associated with pyæmia, owing to the veins being abundant and thin-walled, and considerable tension present from the unyielding condition of the surrounding bony structures. Inflammation of the cranial bones coming on in the course of middle-ear mischief, and causing thrombosis of the lateral sinus, also leads to its development. The presence of large open-mouthed veins in the puerperal uterus favours the onset of the disease after parturition if infective material is present in their vicinity.

When an infective embolus lodges in any region of the body, a thrombus forms upon it, and in this the micro-organisms rapidly develop, and thence pass through the vessel wall into the surrounding tissues, causing inflammation, which is likely to end in suppuration. In the lung many such foci occur, distributed mainly along the posterior border and near the surface; each is sharply limited to a wedge-shaped area of tissue, with the base directed towards the periphery. It is at first reddish in colour from effusion of blood (a *hæmorrhagic infarct*), but soon becomes grayish-yellow from the formation of pus. These abscesses are small, and rarely give rise to any physical signs. Similar collections of pus, preceded or not by an infarct, may be found in any organ of the body. The lungs, acting as a filter to emboli derived from the systemic veins, are naturally the first organs to be affected, and from the abscesses formed therein infection of the arterial system may take place, resulting in fresh suppurative foci in the liver, spleen, kidneys, brain, and in or around joints, etc. If, however, the causative phlebitis is situated in the portal area, the emboli are lodged primarily in the liver, giving rise to what is known as *pylephlebitis.* When the emboli are many in number, the symptoms are severe, constituting **acute pyæmia**; this is sometimes associated with a development of micro-organisms in the blood, producing *pyosepticæmia,* the patient perhaps dying before the secondary abscesses have fully developed. In other cases the general symptoms are due rather to the absorption of toxins from the local foci than to the development of organisms in the blood. If the emboli are few in number, and there is little or no development of microbes in the blood, the disease is termed **chronic pyæmia.**

Clinical History.—The most marked symptom indicating the onset of a case of **Acute Pyæmia** is the occurrence during a period of febrile disturbance of a severe rigor, which is repeated with a sort of irregular periodicity, most frequently at intervals of about twenty-four to forty-eight hours, somewhat simulating an attack of ague (Fig. 20). The rigors do not differ from those occurring in other diseases, but they are very severe, and usually followed by profuse sweating. Between the rigors the temperature may fall to the normal, but more commonly remains above it. The skin is hot and soon develops an earthy or dull yellow tint, together with erythematous or petechial patches. A sweet, mawkish, hay-like smell of the breath is very characteristic. Symptoms of grave depression supervene, and the patient rapidly wastes. The pulse becomes soft and weak, the excretions are diminished, and a certain amount of nocturnal delirium is noticed, but no loss of consciousness. The presence of a bruit in the precordial region may suggest the existence of an infective endocarditis, which is not very uncommon. The tongue varies, but is often red with very prominent papillæ, and becomes dry and brownish. Towards the end of the first week secondary abscesses appear; they are sometimes unaccompanied by local pain or tenderness, and form very rapidly. Joints are not infrequently involved, and may fill with pus, with little or no pain. Unless treated early, rapid disorganization and dislocation may follow. The effusion may be puriform, or thin and oily; it is always, however, swarming with organisms. In the viscera the abscesses are as a rule small and numerous; if they occur in vital organs, such as the heart or brain, death may result from their local development. They are characterized, at first, by the almost total absence of a barrier of granulation tissue, and hence, even when opened early and aseptically, are likely to extend and continue secreting pus, instead of following the usual course of rapid repair which succeeds the aseptic opening of an ordinary acute abscess.

Not uncommonly in these cases painful patches occur here and there in the subcutaneous tissues, accompanied by hyperæmia, which fades away after a few days. These are probably due to the presence of small infective emboli, which the patient has sufficient vitality to get rid of without suppuration.

In **Chronic Pyæmia** the febrile symptoms are much less marked; the abscesses are few in number, and not dangerous unless forming in important structures. Thus, a fatal result ensued from a single abscess which developed in the lateral ventricle of the brain of a patient who had no other symptom of pyæmia except an oscillating temperature: it followed an operation on an infected sinus leading to a kidney already disorganized.

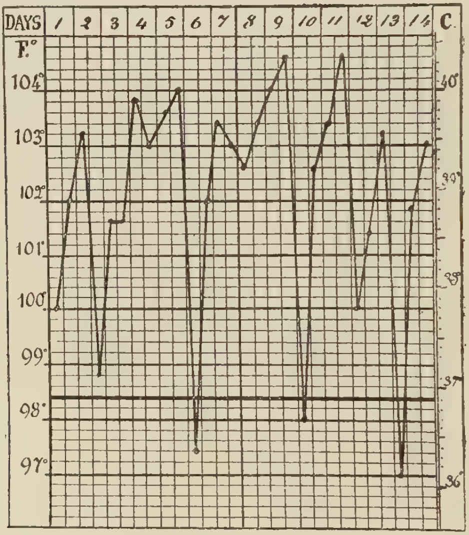

Fig. 20.—Portion of Temperature Chart of a Case of Pyæmia

If the disease results from an *external wound*, the condition of the latter is always most unsatisfactory. It gapes open and presents an inactive, dry, glazed surface, any newly-formed scar tissue breaking down. A layer of healthy granulations is an almost certain barrier against the occurrence of pyæmia, on account of the germicidal power of its constituent cells. If the disease arises in connection with *bone*, the latter structure is usually seen lying bare at the bottom of the wound, denuded of its periosteum, and the cancelli filled with sloughy fœtid medulla or pus.

Post-mortem Appearances.—The veins leading from the infected area are usually in a state of phlebitis; the coats are thickened, and the lumen is filled with soft, pale, disintegrating clot, which extends for a considerable distance; the tissues surrounding the vein are also involved in the suppurative process (periphlebitis). Secondary abscesses are found in various parts of the body, most frequently in the lungs, and their different stages can be clearly demonstrated from the embolic colonies of micrococci, through the stage of hæmorrhagic infarction to the complete abscess. The general signs common to all cases of death from toxæmia (p. 91) will also be manifest.

The **Diagnosis** of pyæmia should not be difficult in the majority of cases; but when it originates without any obvious external wound from a deep-seated focus, or if the importance of some local lesion has not been appreciated, the initial symptoms may be mistaken for those of acute rheumatism or ague.

The **Prognosis** depends upon the inherent vitality of the patient and the virulence of the disease. In acute cases it is extremely grave, probably terminating in a week or ten days, whilst in the chronic type recovery is not only possible, but probable, if the local abscesses are favourably situated.

The ideal **local Treatment** consists in preventing, if possible, the further contamination of the general blood-stream by the dissemination of infected emboli. This can sometimes be accomplished, in the case of a limb, by amputation well above the local lesion; or if the medullary cavity of a bone is the source of trouble, it may be possible to scrape out the gangrenous and offensive medullary tissue, and disinfect the cavity: or if it is due to a wound in the soft parts, it may be feasible to dissect out the implicated vein and surrounding tissues, or at any rate to remove the disintegrating clot after placing a ligature upon the vessel between the thrombus and the heart. A typical illustration of such treatment is that adopted for infective phlebitis of the lateral sinus complicating disease of the middle ear, where, after tying the internal jugular in the neck, the sinus is exposed by the trephine or gouge, opened, and all the infected clot removed, partly from above, partly from below; admirable results have been thereby obtained. Where, however, such ideal treatment is impracticable, all that the surgeon can undertake is to render the primary focus as healthy as possible by free relief of tension and close care in asepsis. The *abscesses* must be dealt with, when possible, by early opening and draining them, or by aspiration; such wounds often heal well, and joints which have been distended with pus may recover with free mobility. Occasionally, however, although rigid asepsis has been maintained, the suppuration continues, and even sloughing of the abscess wall may follow. If the general condition can be improved, a barrier of granulation tissue will form in time, and repair be established.

Constitutional treatment consists in supporting the patient's strength by nourishing diet and stimulants, and in taking precautions to avoid bedsores or any local injury. Salicylate of quinine may be administered, though its value is doubtful. The antistreptococcic serum (p. 27) may also be utilized, and it may do good in cases which have not progressed too far. Vaccine treatment may also be tried.

CHAPTER VI.

ULCERATION.

Ulceration has been defined as the 'molecular or particulate death of a part,' by which is meant the disintegration of the superficial tissues, which liquefy and disappear, and usually without any obvious slough. It differs from gangrene in that the latter term is used to denote the simultaneous loss of vitality of a considerable portion of tissue. The two processes are, however, often closely associated—in fact, both signify tissue necrosis; in the former the dead particles are not always visible to the naked eye, whereas in the latter the necrotic portions, if superficial, can always be seen.

An **Ulcer** is an open wound or sore which tends to persist, probably as a result of pyogenic infection, but may under favourable circumstances heal. Any part of the surface of the body may be affected, but especially the lower extremities, whilst all the mucous membranes suffer similarly. Many small ulcers may be present, and then not unfrequently are caused by infection one from another; or the ulcer may be solitary and of large dimensions.

It is almost impossible to classify ulcers, so multifarious are they in type and so wedded are we to an old-standing, inexact terminology. It must suffice to suggest that in surgical practice three chief **classes** are met with—viz.:

I. *Ulcers due to traumatism or to non-specific pyogenic bacteria, e.g.*, the spreading, healing, chronic, etc.

II. *Ulcers due to specific bacteria, e.g.*, soft chancre, lupoid, tuberculous, syphilitic, etc.

III. *Malignant ulcers, e.g.*, rodent, epitheliomatous, scirrhous, and fungating.

Any form of surface irritant, whether chemical, thermal, mechanical, or infective, may cause ulceration, and all the factors predisposing to inflammation will hasten its occurrence. Faulty nutrition, whether from anæmia or from long-standing congestion, is particularly liable to further the ulcerative process; thus, in the lower extremity it is predisposed to, on the one hand, by arterial disease which leads to anæmia, or, on the other, by the passive congestion dependent on varicose veins. General debility, such as results from Bright's disease, diabetes, etc., will also favour the occurrence of ulceration. Moreover, when any part becomes anæsthetic, or is cut off from its trophic centres, the continued presence of an irritant may not be appreciated, and hence destructive inflammation occurs, *e.g.*, corneal ulcer following section of the fifth nerve, or perforating ulcer of the foot in tabes. In malignant disease the projection of the mass of the growth may expose it unduly to irritation; but the chief cause of ulceration is the replacement of the deeper layers of the skin or mucous membrane by the cells of the neoplasm, so that when the superficial epithelium wears off or is lost it cannot be reproduced.

I. Ulcers due to Traumatism or to Non-Specific Pyogenic Bacteria.

Clinical History.—Every ulcer of this class tends sooner or later to recovery, and so may be said to pass through three stages, viz., (1) that of ulceration proper, or extension; (2) a stage of transition, or preparation for healing, which may be short or long, according to whether the ulcer is running a rapid or a slow course, and persists until the surface is covered with granulations; and (3) the stage of healing or repair. It must be clearly understood that the first stage alone represents the true ulcerative process; when this ceases, merely a superficial loss of substance, the result of the preceding ulceration, remains, and to this sore the term ‘ ulcer ’ would scarcely be applied, unless it tended to persist. If every simple ulcer passes through these three stages, then *every variety of simple ulcer must necessarily be in one of the three stages*, and hence may be described as a modification of a typical condition representing the stage to which it belongs. Naturally, in a large ulcer the three stages may co-exist, or a healing ulcer may from intrinsic or extrinsic causes relapse again to the stage of tissue destruction.

Stage I.: Ulceration Proper, or Extension.—The special characteristic of this stage is that destructive changes are progressing with greater or less rapidity, and hence the ulcers may be described as inflamed, spreading, or sloughing.

Naked-eye Appearances.—*Surface*, covered with ashy gray or dirty yellow material, partly slough, partly lymph, partly breaking-down tissue; no granulations are present; the tendency to slough is most marked when the organisms are particularly virulent, or if the resistance of the tissues is much diminished; *discharge*, considerable in amount, thin, sanious, and often irritating and offensive, rarely purulent; *margins*, thickened and inflamed, and the surrounding tissues often œdematous and infiltrated; *edge*, sharply cut and well defined; the *base* of the ulcer is thickened and fixed to the underlying structures. In fact, the phenomena are those of an acute spreading superficial inflammation, which terminates in tissue destruction.

Treatment resolves itself into removing the cause, and protecting the surface from mechanical or other irritation. The inflamed part must be kept at rest, and if necessary raised from a dependent position (*i.e.*, the leg must not be allowed to hang down), whilst the sore is dressed with moist and warm antiseptic applications, such as a boracic fomentation. When the parts are very offensive, a charcoal and linseed-meal poultice may be first employed.

Stage II. : The Transition Period comprises all the changes which occur from the termination of the ulcerative process proper to the time when healing is fully established by the wound becoming covered with granulations. In short, it may be described as the stage of *preparation for healing*.

Naked-eye Appearances.—When the destructive process has ceased, the surface of the ulcer begins to clean, and becomes, as it were, glazed over; sloughs are either removed in the dressing or absorbed. The discharge becomes less abundant and more serous in character, and the angry red blush is replaced by a rosy hyperæmia. The infiltration of the base also diminishes, so that the tissues around are less fixed and more supple. The film on the surface becomes more and more defined, and in the course of time, shorter or longer, according to circumstances, little red spots make their appearance here and there; these gradually increase in number and size, and coalesce, until the whole surface is covered by what has now become granulation tissue. The processes occurring in this stage are: (*a*) the removal of the sloughs; (*b*) the covering of the surface with a cellulo-plastic exudation; and (*c*) the vascularization of this newly-formed material, and its conversion into granulation tissue. All these changes do not necessarily go on equally all over the surface of the ulcer at the same time, and hence much variety in its appearance may be manifested; whilst at times the reparative changes may come entirely to a standstill. Hence *all the forms of chronic ulcer which are neither spreading nor actively healing may be included in this transitional stage*, viz., the indolent or callous ulcer, the irritable, the varicose, etc.

The **Indolent or Callous Ulcer** occurs most frequently on the legs of women about the middle period of life. The size varies greatly, but it is sometimes so extensive as to involve the whole circumference of the limb. The *surface* is usually smooth and glistening, and of a dirty yellow colour, with perhaps a few badly-formed granulations; the *edges* are hard and sharply cut, and elevated considerably above the surface, whilst the skin around may be heaped up over the edge, and either covered with sodden cuticle or congested. The skin of the limb is often deeply pigmented from chronic congestion, the pigmentation starting in the separate papillæ as maculæ, which gradually coalesce. The *discharge* is purulent or serous, and may be so abundant and irritating as to cause eczema of the parts around, and thus give rise to one form of *eczematous ulcer*. The *base* is adherent to the underlying tissues, fasciæ, etc.; and this constitutes one of the main difficulties in healing, as contraction is thus prevented. If the ulcer is situated over a bone, such as the tibia, chronic periostitis results, and a subperiosteal node is formed, corresponding exactly to the size and situation of the ulcer, forming a mushroom-shaped projection, and possibly going on to necrosis or to diffuse osteo-periostitis of the whole bone. These ulcers are sometimes very painful from pressure on cutaneous nerves, or from a localized cellulitis, associated, perhaps, with inflammation of veins and lymphatics. Thrombosis not infrequently occurs in both sets of vessels, leading to chronic œdema of the foot, often of a very solid, brawny type, and the limb may even pass into a condition of pseud-elephantiasis.

A somewhat similar condition may also follow large burns on any part of the body; healing proceeds to a certain extent, and then stops from the fact that the contraction of the cicatricial tissue already formed interferes with the vitality of the part still unhealed by compressing the vessels, and so cutting off the granulations from their source of nutriment.

The so-called **Irritable Ulcer** is usually met with in this stage. Its chief peculiarities are the position, generally in the neighbourhood of the ankle, and the pain which accompanies it. The surface of a healing or chronic ulcer can usually be touched without the patient complaining; but in this variety the pain is excessive, especially at night. It was pointed out by the late Mr. Hilton that, if a probe is run lightly over the surface of such a sore, one or more spots will be indicated as the chief seats of the pain, the rest being insensitive. In all probability, nerve filaments are there exposed, as the pain has a very marked burning or shooting character.

The **Varicose Ulcer** occurs in the leg of a patient who is the subject of aggravated varicose veins, especially when the smaller venules are involved. The skin becomes passively congested, and its nutrition impaired; any injury or abrasion, which would readily heal in a sound limb, is likely under such circumstances to give rise to a chronic sore. Again, it may be preceded by eczema resulting from the irritation of dirt or the friction of hard trousers, whilst occasionally it is due to the yielding of the thinned skin which forms the only covering of a much dilated vein, an accident often leading to severe hæmorrhage. The characters of a varicose ulcer in the main correspond to those of the indolent variety; it is usually situated on the inner and lower portion of the leg, whilst syphilitic sores are more often placed nearer the knee and on the outer side.

Treatment in this stage differs according to the conditions present. If it is merely a passing phase in the progress of an ulcer tending rapidly to repair, the same course of treatment should be adopted as in the earlier period, viz., rest and protection from irritation. It may be advisable to shield the surface from contact with dressings by the intervention of a small portion of purified 'protective'—*i.e.*, oiled silk coated with dextrin—so that the reparative material may not be damaged during their removal.

The **Chronic Ulcer** needs much care in its treatment, and some cases require operative interference. Rest in a more or less elevated position is absolutely essential in order to relieve the congested condition of the limb; whilst if the surface is foul, a charcoal poultice may be beneficial, or the sore may be dusted over with iodoform, and boracic fomentations applied. This may be preceded in some cases by touching the surface with solid nitrate of silver, or with a solution of chloride of zinc (40 grains to 1 ounce).

Pressure has been found of considerable service in the treatment of these ulcers; an ordinary bandage, reaching from the toes to the knee, will suffice in some cases, a suitable dressing of boric acid ointment, with perhaps some resin ointment added to make it more stimulating, being applied beneath it. *Martin's* indiarubber *bandage* is more useful when the veins are much enlarged.

The method of dealing with chronic ulcers suggested by Professor Unna, of Hamburg, has given excellent results. It consists in the use of an adhesive plaster, made up as follows: Gelatin, 5 parts; oxide of zinc, 5 parts; boric acid, 1 part; glycerine, 8 parts; water, 6 parts; to this ichthyol (5 per cent.) may be added with advantage. The limb is first washed thoroughly with soap and water, and purified with carbolic or sublimate lotion. It is then wrapped round with a single layer of sterile gauze, and the paste, liquefied by placing it in a gallipot in a saucepan of boiling water, is applied over it with a paint or paste brush. Another layer of gauze is placed over the paste and a thin bandage over all, and the whole allowed to dry. Where there is extensive varix, the paste should extend from the ankle to the knee, and may sometimes include the foot. If there is much discharge, the ulcer should not be covered, and the dressing should be reapplied daily; but after it has diminished in amount, the paste may be carried right over the sore, and the whole application left in position for a week, or even longer.

When the edges are very indurated and thickened, and all action is at a standstill, Syme's suggestion may be followed, viz., to blister the whole surface, as well as the surrounding skin. A more satisfactory method, but requiring an anæsthetic, is to scrape the surface with a sharp spoon, and then to rub in a strong solution of chloride of zinc. When healthy action has been obtained, assistance in healing may be secured by the use of such stimulating applications as scarlet-red (a coal-tar derivative) used for twenty-four hours in the form of a 4 to 8 per cent. ointment, after effective purification, followed for two days by boric acid ointment, and then repeated; or the liquid extract of the common comfrey (*Symphytum officinale*), the active agent in which is allantoin, will stimulate the growth of granulations; or allantoin itself may be employed in a 5 per cent. solution. Any of these agents will hasten a cure. If, however, the surface to be healed is very extensive, skin-grafting may be employed, if necessary; it is useless to undertake this, however, unless the patient can promise to rest for a prolonged period, and even then elastic support will be subsequently required. In bad cases where a considerable portion of the circumference of the limb is involved, when the ulcer is very callous and its base attached to the tibia, causing severe pain at night from chronic periostitis, and especially when the patient cannot obtain prolonged rest, *amputation* may be the best treatment. Farabœuf's amputation at the site of election can often be undertaken with advantage.

Where varicose veins exist, treatment is of little avail unless these are efficiently dealt with either by operation or by some suitable support, such as Unna's paste. It is often undesirable to attack the veins locally owing to the dirty condition of the ulcer, which must be dealt with by rest and fomentations. Operation consists either in removal of the dilated veins at a higher level, or in Trendelenburg's operation (*q.v.*) in suitable cases.

The **Irritable Ulcer** may be treated by discovering the painful spots, and incising the tissues just above them with a knife, so as to divide the exposed nerves; but thorough scraping under an anæsthetic is preferable.

The **Eczematous Ulcer** must be dealt with differently from the others, or the eczema will be aggravated. Soothing applications are needed, such as lead lotion, and when once the acute stage has passed, tarry preparations (liq. carbonis detergens, 1 ounce to 1 pint of lotio plumbi), or an ichthyol ointment (5-10 per cent.), may be beneficially employed. A mixture of benzoate of zinc and boric acid ointments is a very useful application, or Unna's paste with ichthyol may be utilized.

Stage III.: Repair having now been fully established, we have to deal with, not a healthy ulcer, for such a condition cannot exist, but a healthy granulating wound, the result of ulceration, or, as we call it, to avoid confusion, a 'healing ulcer.'

A **Healing Ulcer** is characterized by the following conditions: *Surface*, smooth and even, shelving gradually from the skin, and covered with healthy granulations; these present a florid red appearance, are painless, and bleed, but not readily, on being touched. The *discharge* varies according to the plan of treatment adopted: if the surface is kept at rest and free from all irritants, the discharge is merely serous; but should the wound become infected, or be dressed with irritating antiseptics, ordinary pus is formed. The surrounding skin is soft, flexible, and free from inflammatory congestion, and the *base* is similarly free from fixity. The *margins* present a healing edge, which has been described as manifesting three coloured zones: within is a *red* area consisting of granulation tissue, covered by a single layer of epithelial cells, which cannot be seen except in a good light; next comes a thin dusky purple or *blue* line, where the granulations are covered by a few layers of epithelium, and the circulation is becoming retarded owing to cicatricial development; whilst outside is a *white* zone due to the heaping up of sodden cuticle upon the healthy or healed part.

The method of repair in such a wound consists in a change of the deeper layer of granulations into fibro-cicatricial tissue, which gradually contracts and is finally covered with epithelium. For full description see Chapter X.

If emollient applications are used too long, the granulations become pale, protuberant, and œdematous, and the healing process is temporarily checked. A depressed general condition of the patient, or a varicose condition of the veins, may also account for this, and the term *a weak ulcer* is applied to it, whilst the prominent flabby granulations are popularly known as *proud flesh*.

Treatment.—The part must be kept at rest, and if the leg is the seat of the trouble, it should not be allowed to hang down. The wound must be protected from injury by a dressing which can be removed without damaging the surface. A piece of sterile protective, the exact size of the lesion, may be placed over it, and covered with sterile gauze, or the wound may be dressed with a simple ointment (*e.g.*, ung. acidi borici, diluted with an equal part of vaseline) spread on sterile butter-cloth or lint. If the granulations become too prominent, they may be lightly touched with nitrate of silver, or a stimulating lotion applied, such as that known as lotio rubra (℞ Zinci sulphatis, gr. ii.; tinct. lavandulæ co., spir. rosmarini, āā ♏xx.; acidi borici, gr. x.; aquam destill. ad ℥i.).

Large ulcers require assistance in order to obtain expeditious healing, otherwise a time comes when the contraction of the cicatricial tissue interferes with the nutrition of the granulations, and retards the healing process. To obviate this difficulty, skin-grafting is frequently utilized.

Skin-grafting, or the transplantation of more or less of the thickness of the skin from a healthy to a healing part, was introduced by Reverdin in 1869, and has since been much elaborated. The following are the chief methods employed:

1. Transplantation of small pieces of the cuticle and cutis, Reverdin's original plan. A small portion of the cutaneous tissue is pinched up with or without forceps, and removed by a pair of sharp curved scissors. It should include the cuticle and a portion of the cutis vera, so that a drop or two of blood will slowly ooze from the denuded surface. The graft is gently placed cutis downwards on the surface of the granulations and covered with purified protective. Many of these may be applied at the same time, and the whole wound carefully dressed and protected. If there is much discharge, the grafts will not 'take'; but if the surface is healthy, there should be no difficulty in getting them to grow. Usually they disappear for a day or two, from the cuticle becoming softened or disintegrated; but soon the epithelium of the cutis spreads, and makes itself visible as a distinct centre of repair.

2. Transplantation of large portions of cuticle as suggested by Thiersch. This method consists in removing large strips of cuticle with a razor, and implanting them on a fresh wound or on a raw surface denuded of granulations by scraping; all hæmorrhage must be previously stayed by pressure. In cutting the strips of cuticle care must be taken to make them as thin as possible; the papillæ are always encroached on, however, and hence some amount of blood escapes, in which the grafts are allowed to remain soaking until required for use. The grafts are applied in such a way that they overlap each other and also the margins of the defect. There is always some tendency for the edges to turn in, and this must be prevented by gentle manipulation. They are then dressed with dry sterile gauze, though some surgeons still prefer to keep the grafts covered with protective, or with perforated tin

or thin silver-foil. There is usually no need to look at the wound for some days. The outer sides of the thigh and arm are the best places from which to take grafts; the wounds caused by their removal are dressed by sterile gauze over protective or by gauze soaked in picric acid, and usually heal quickly, if the razor has not encroached on the subcutaneous tissues. The scar which results from the healing of the grafts is generally soft and supple, and free from the tendency to excessive contraction which marks the ordinary cicatrix.

3. The whole thickness of the skin is used in some instances (*Wolfe* graft). The graft is cut rather larger than is necessary, to allow for shrinkage, and *all* subcutaneous tissue and fat removed therefrom. It is applied to the raw surface of the wound after scraping away all granulations, and stitched into position. It may also be applied to the raw surface of an operation wound.

II. **Ulcers due to Specific Bacteria.**

The different forms of infective ulcers met with in surgical practice will be described under the appropriate headings in different parts of the book. It will suffice here to mention them:

Soft Chancre (p. 149).—This may be taken as a type of all infective ulcers, clearly showing the stages of infection, incubation, ulceration, and repair.

Ulcers due to Syphilis:

(*a*) The primary sore (p. 155).
(*b*) Secondary ulcers, mainly of mucous membranes, but sometimes involving the skin (p. 159).
(*c*) Intermediate, rupial, or ecthymatous sores (p. 161).
(*d*) Tertiary ulcers from the disintegration of gummata (p. 163).

Phagedenic ulceration (p. 157) is usually associated with syphilis.

Ulcers due to Tubercle:

(*a*) The lupoid ulcer, due to a cutaneous tuberculosis (Chapter XVII.), or
(*b*) The tuberculous ulcer, arising as a rule from the bursting of a subcutaneous or submucous tuberculous abscess (p. 182).
(*c*) Various other tuberculous ulcerative lesions of the skin are described by dermatologists under the title 'scrofulodermia,' whilst Bazin's disease (or erythema induratum) is possibly tuberculous in origin.

III. **Malignant Ulcers.**

These are due, as has already been pointed out, not to any inflammatory process, but to the actual replacement of the skin by the growth, so that loss of substance necessarily ensues. They will be described in Chapter IX.

CHAPTER VII.

GANGRENE.

BY gangrene, or necrosis, is meant the simultaneous loss of vitality of a considerable area of tissue. If the process is limited to the soft parts of the body, it is often termed *sloughing* or *sphacelation,* and the dead mass a *slough* or *sphacelus ;* if a tangible portion of bone dies, the necrosed mass is called a *sequestrum ;* while the term *gangrene* is more especially applied to a necrotic process affecting simultaneously the hard and soft tissues of a limb.

General History of a Case of Gangrene.

Signs of Death.—Death of a limited portion of the body can be recognised prior to the supervention of evident post-mortem changes within it by five characteristic signs:

1. Loss of pulsation in the vessels.
2. Loss of heat, since no warm blood is brought to it.
3. Loss of sensation in the dead part, although much pain of a referred type may be experienced whilst death is occurring.
4. Loss of function of the gangrenous mass, which, if it is a limb, lies flaccid and motionless.
5. Change of colour, the character of which depends on the amount of blood present at the time of death; if the part is full of blood, it becomes purple and mottled; if anæmic, a waxy or cream colour results.

These five signs may be in measure present when the vitality of a limb is seriously depressed, as by ligature of the main vessel or by its embolic obstruction; but if they continue for any length of time, death is certain to ensue. Sometimes it is a little difficult to determine whether a part is dead, especially when it is engorged with venous blood and the arterial pulsation has ceased; if living, it will usually be found that pressure causes some modification of the colour, and that the discoloration returns when the pressure is removed.

Changes occurring in the Dead Tissues.—The character of these depends mainly on the condition of affairs at the time of death, and whether or not putrefaction supervenes.

PLATE II.

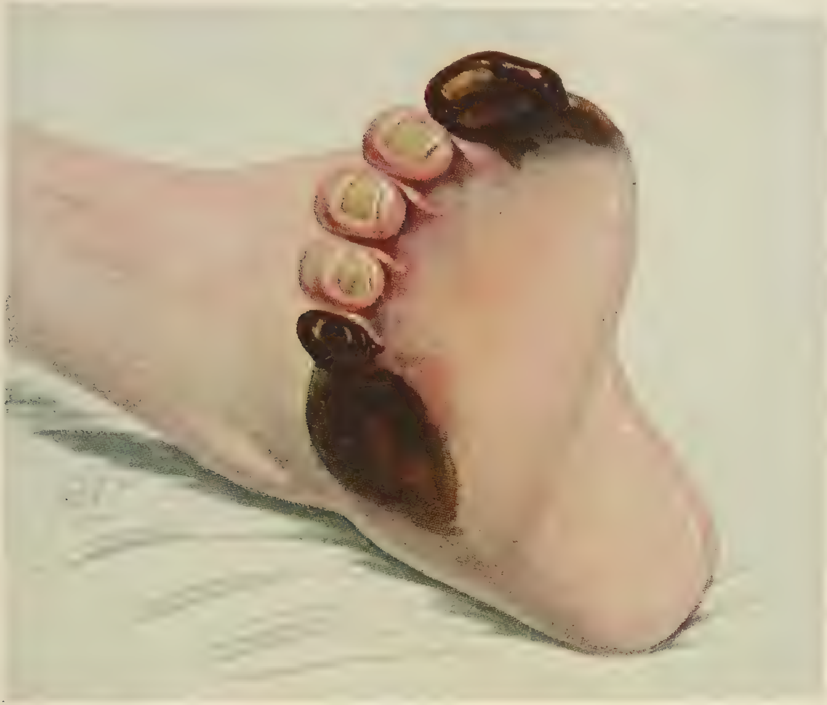

Fig. 1.—Senile Gangrene of Foot. In this case amputation was performed above the knee, and the popliteal artery was found to be very atheromatous and in a condition of thrombosis.

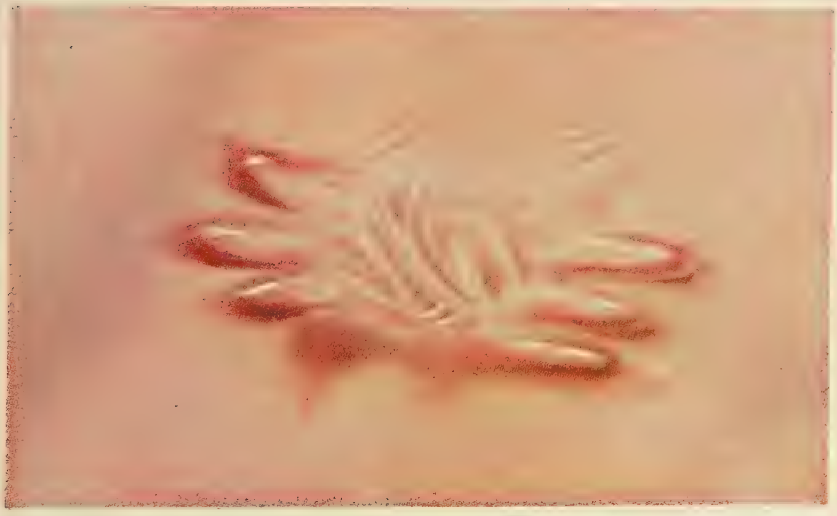

Fig. 2.—Keloid of Thoracic Wall.

[*To face page 108.*

1. **Dry Gangrene** (= *death + mummification*) can only occur when the tissue involved is, previous to its death, more or less drained of its fluids. The usual cause is chronic arterial obstruction, as brought about by arterio-sclerosis or calcification of the terminal arteries, to which a sudden or gradual complete occlusion of the main trunk is often superadded. The dead part becomes hard, dry, and wrinkled, and is of a dark brown or black colour from the diffusion of the disintegrated hæmoglobin (Plate II., Fig. 1). The more fleshy parts (*e.g.*, above the ankle) rarely undergo perfect mummification, and are often considerably inflamed, and, if bacteria be admitted, horribly offensive.

2. **Moist Gangrene** arises when a part of the body full of fluid dies, and is especially associated with conditions which involve venous obstruction as well as a sudden arterial block—*e.g.*, in traumatic gangrene due to pressure upon, or rupture of, the main artery. Obviously, such a condition is well suited for the development of the organisms, which always exist in numbers on the skin, and unless the most vigorous efforts are made to render it aseptic before or immediately after death, moist gangrene is certain to be associated with putrefaction; but it must be clearly understood that the latter is no essential part of the gangrenous process.

Aseptic Moist Gangrene is characterized by the dead tissues becoming more or less discoloured, either purple or any shade from black to yellow, green or white. It remains of much the same size and consistency as at the time of death so long as it is kept from contamination, and is then simply and quietly cast off from the surrounding tissues without any obvious inflammatory disturbance, although a certain amount of toxæmia may result from the absorption of various products from the dead tissues.

Septic or Putrid Moist Gangrene (Fig. 21) is necessarily associated with a rapid breaking-up and disintegration of the mass, which becomes black, green, or yellow. The cuticle is raised from the cutis vera by blebs containing stinking serum, or even bubbles of gas, and these can be readily pressed along under the epidermis for some distance. The tissues of the limb are soft and lacerable, and on grasping it emphysematous crackling is usually noted.

The **Later History** of a gangrenous mass depends entirely on its asepticity or not, and on its bulk.

(*a*) If the necrotic area is small in size and aseptic, it may, under favourable circumstances, be entirely *absorbed* in the same way as is a catgut ligature. This is often observed after sloughing of small portions of amputation flaps; if the part is kept dry and aseptic, it is gradually removed, and when the process is completed a small dark scab will fall or be picked off, and a cicatrix be found beneath it. In a similar way dead bone may be absorbed, if the sequestrum is not too large or too dense, and if it is in close proximity to healthy vascular tissue. The dead portion is first invaded by small round cells, presumably leucocytes, which infiltrate and gradually remove the part; granulation tissue replaces it, and this in turn is converted into a cicatrix, and covered with cuticle in the usual way (see Repair, Chapter X.).

(*b*) If the mass, though aseptic, is of such a size, or consists of such tissues, as to prevent its total absorption, or if the vital activity of the patient is lowered, a modification of the same process results in *partial absorption* of the dead material, *whilst the remainder is cast off and separated by a simple process of anæmic ulceration.* The dead part immediately contiguous to the living is removed and replaced by granulation tissue, and this change continues advancing into the mass until the layer of granulations which has penetrated furthest is at such a distance from its nutritive basis as to be unable to derive from it sufficient pabulum, owing to the contraction of the cicatricial tissue which is forming behind; and then a simple ulcerative process from defective nutrition causes a line of cleavage to form between the living and dead, and by this means the latter is separated from the body. The size of the portion thus cast off is distinctly less than that of the original necrotic mass. This process is associated with no local inflammatory reaction, and but little resulting constitutional disturbance; it is slow in progress, but there are none of the risks attaching to the more rapid septic proceeding. Of course, the denser and harder the tissues, the longer they take in separating, and hence when a whole limb is involved it is possible for the soft parts to have separated, and the wound caused thereby to have cicatrized before much impression has been made on the bones. Considerable retraction ensues, giving rise to a 'conical stump' from the apex of which the bone protrudes.

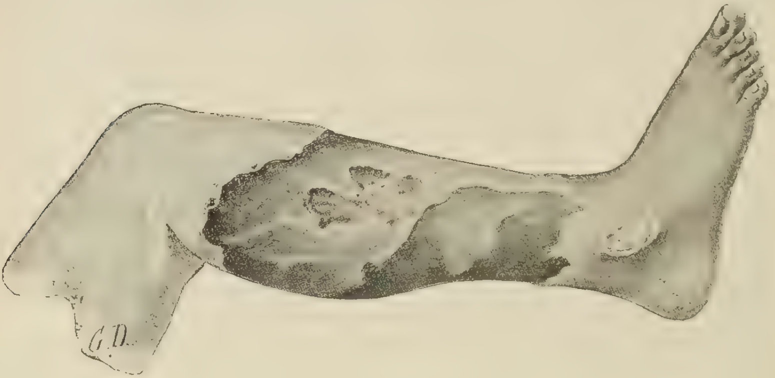

Fig. 21.—Septic Moist Gangrene of Leg from Penetrating Wound of Femoral Artery.

(*c*) If the gangrenous portion is septic, its *separation* is accomplished *by an inflammatory act taking place in, and at the expense of, the surrounding living tissues.* The extent of the gangrene is primarily indicated by a *line of demarcation,* due to the change in colour occurring in the dead part, the living tissues retaining their normal hue. The irritation of the chemical products formed in the necrosed mass causes inflammation in the surrounding structures, which ends in suppuration, whilst a layer of granulation tissue forms at the limit of the living portion, and thus the *final line of separation* is produced. Clinically, one notices in this latter stage a bright red line of hyperæmia at the extremity of the living tissues, which gradually spreads and deepens until about the eighth or tenth day, when, if the cuticle is intact, the living and dead parts are separated by a narrow white or yellow line, which is proved, on pricking the epidermis, to be due to the presence of a layer of pus; as the pus escapes, a shallow groove is seen running between a granulating surface on the side of the living tissues and the gangrenous mass. This process, gradually extending through the whole thickness of the limb, is accompanied by the local signs of inflammation and by fever, the degree of the latter depending on the amount of toxic material absorbed. The inflammation, moreover, is not always limited to the line of separation, but may spread upwards along the lymphatics or veins, or in the fascial and muscular planes, until, perhaps, the whole limb is involved in an extensive suppurative process.

The **Constitutional Symptoms** of gangrene may be described under two distinct headings:

(*a*) Those general conditions which predispose to the occurrence of gangrene, and which are mainly of a debilitating character, affecting either the composition of the blood or the vitality of the limbs. General diseases, such as diabetes and albuminuria, may be present, as also the constitutional results of a vicious life, whilst local evidences of malnutrition often manifest themselves before the onset of gangrene.

(*b*) Those conditions depending on the presence and connection with the body of the dead tissue. Various forms of toxæmia result, usually causing fever, asthenic in type and variable in amount. Pain, moreover, is frequently a prominent feature in some forms of gangrene, and the patient is liable to become exhausted from this cause.

But little need be said as to the **General Treatment** of gangrene, beyond that the strength of the patient must be maintained by plenty of easily assimilable food, sufficient stimulant, and tonics. Pain and sleeplessness must be combated by the administration of a suitable amount of opium or morphia, if the kidneys are healthy. Diabetes and albuminuria need dietetic and therapeutic measures in order to limit, if possible, the excretion of sugar and albumen. The **Local Treatment** is discussed below.

Varieties of Gangrene.

The following classification is one which, though admittedly imperfect, does in a measure group together allied types of the affection, and will serve as a useful one for practical purposes:

I. **Symptomatic Gangrene,** or that predisposed to by preceding vascular or general conditions, and where a trauma, if present at all, is of very slight significance.

- (*a*) Gangrene from embolus.
- (*b*) Senile gangrene.
- (*c*) Gangrene from arterial thrombosis (non-senile).
- (*d*) Diabetic gangrene.
- (*e*) Raynaud's disease.
- (*f*) Gangrene due to ergot.

II. **Traumatic Gangrene,** which may be due to direct or indirect injury, and where the damage done to the vessels or tissues by the trauma is the immediate cause of the loss of vitality. Two varieties may be described, viz.:

- (*a*) The indirect, where the lesion involves the vessels of the limb at some distance above the spot where the gangrene occurs.
- (*b*) The direct, where the gangrenous process is limited to the part injured.

III. **Infective Gangrene,** which arises from the activity and influence of micro-organisms.

- (*a*) Acute inflammatory or spreading traumatic gangrene.
- (*b*) Wound phagedena and hospital gangrene.
- (*c*) Noma and cancrum oris.
- (*d*) Carbuncle and boil.

IV. **Gangrene from Thermal Causes**—frost-bite and burns.

Each of these varieties must now claim separate and individual attention.

I. Symptomatic Gangrene.

(*a*) **Embolic Gangrene.** (For general details as to emboli, see Chapter XIV.). When the main artery of a limb becomes blocked by a simple embolus, the condition is exactly similar to that which obtains after ligature, and under ordinary circumstances should not lead to gangrene; but if either the general or local vitality is much reduced, the occlusion of the main trunk may be sufficient to determine the death of more or less of the limb. Thus it may occur: (i.) Where the embolus consists of a fibrinous vegetation detached from one of the cardiac valves in a case of endocarditis following rheumatic or other fevers. The general nutrition has been depressed by the preceding fever, the heart's action is weak, and the circulation possibly impeded by the valvular lesion, so that the occlusion of a main trunk, even in a young person, is often sufficient to determine gangrene. (ii.) It also follows when a detached atheromatous plate blocks the main vessel of a limb previously rendered anæmic by arterial degeneration, an occurrence not unusual in elderly people.

Emboli are most commonly arrested at the sites of division of the main trunks (Fig. 22, A), or where the calibre is suddenly diminished by the origin of a large branch, the embolus often saddling over the bifurcation, and thus, as it increases in size by the subsequent deposit thereon of fibrin, effectually closing both branches (Fig. 22, B). In the lower limb it occurs at the division of the femoral or popliteal; in the upper, at the origin of the superior profunda, or where the brachial divides.

The chief early **Symptom** is sudden severe pain experienced both at the point of impaction and also down the limb along the course of the vessel. Pulsation below the block ceases, the limb becomes useless and devoid of sensation, and its temperature rapidly falls. If the vessels are healthy, stagnation of blood in the veins is an early result, the terminal portion of the limb becoming congested and œdematous, and finally passing into a condition of moist gangrene. If, however, the terminal arteries are calcified or atheromatous, so that the limb is in a state of chronic anæmia, dry gangrene is likely to follow. The process starts peripherally, and spreads gradually upwards until it reaches a level where there is sufficient circulation to maintain the life of the part. This usually obtains in the neighbourhood of a joint, since there is always a more free anastomosis here than in the interarticular portions of the limb; thus, in the leg the gangrene is arrested either immediately above the ankle or below the knee.

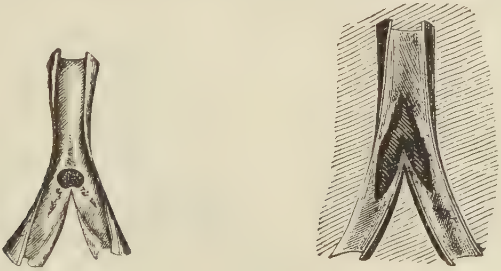

FIG. 22.—DIAGRAMS OF EMBOLUS SADDLING THE BIFURCATION OF AN ARTERY.

In A the embolus is seen, and the commencement of a thrombus on it, but not yet obstructing the vessel: in B both branches of the trunk are blocked by the growth of the clot.

Treatment.—The first requisite is to prevent the advent of infection, even before any absolute signs of death are manifest. The nails should be cut, and the whole limb thoroughly purified (Chapter XI.), special attention being directed to the intervals between the toes and the semilunar folds of the nails. It should then be wrapped in a dry sterilized dressing, with plenty of wool, and bandaged. The limb is kept slightly raised so as to assist the venous return without interfering with the arterial supply, and by this means gangrene may be prevented. Vigorous massage so as to break up the clot and drive it on into the peripheral vessels has been advocated. A few instances are also on record of the artery being opened, and attempts made to extract or tunnel the clot; the results have not been very favourable. If, however, gangrene ensues, the same measures as to the maintenance of asepsis must be continued until a natural line of separation forms. In old people with dry gangrene the question of amputation is decided by rules similar to those for the senile type: but in young people amputation through the living tissues a little above the line of separation is all that is required, and the period for this must be determined by the local and general conditions. If the parts are aseptic, the amputation may be delayed; but if spreading inflammation exists, one may have to remove the limb higher up than would be otherwise necessary, and this even before any line of separation has formed.

(*b*) **Senile Gangrene** occurs in elderly people, and is the result of imperfect nutrition of the tissues (Fig. 23). The toes are most frequently affected, but it is also seen in the hand, and may attack the nose, ears, or even the tongue.

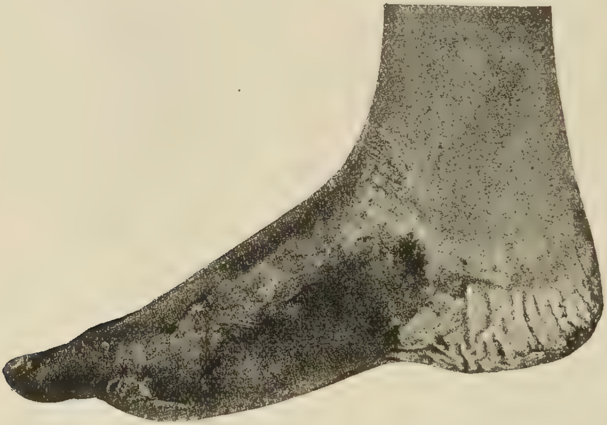

FIG. 23.—SENILE GANGRENE.

Causes.—These are to be found mainly in the condition of the circulatory organs. (*a*) *Calcareous degeneration* of the smaller arteries of the limb or part is always present, as also possibly atheroma of the larger trunks. The vessels become pipe-like and inelastic in consequence, and incapable of accommodating themselves to the requisite variations in the blood-supply. Hence a fixed minimal amount of blood enters the limb, which passes into a chronic state of anæmia and malnutrition, whilst the tunica intima is often so rough as to predispose to thrombosis with or without injury. (*b*) *A weak heart* is generally present, leading to low pulse tension, and increased difficulty in propelling the blood through the rigid and narrowed vessels; and (*c*) the *condition of the blood* may be *impoverished* by albuminuria or glycosuria. When such predisposing factors are present, anything that results in (*d*) *thrombosis either in the main* *trunks or in the peripheral arterioles or capillaries* is likely to determine the onset of gangrene. Thrombosis of the main vessels may be due to a blow or strain which often passes unnoticed, or more frequently arises from a gradual deposit of fibrin on the already roughened walls. If the obstruction originates in the smaller trunks or capillaries, it is generally brought about by inflammation following some slight injury, such as striking the ball of the great-toe against the table, or even cutting a corn. Exposure to cold may also act as an exciting agent. In either case the clotting extends for some distance, and the height to which the gangrene spreads will vary accordingly.

Symptoms.—Evidences of malnutrition of the limb have probably been present for some time in the form of cramp and pain in the muscles, which become fatigued rapidly, or of sensations of pins and needles or numbness. The pulsation in the tibials may be so slight as to be scarcely perceptible, and the whole limb is shrivelled and feels cold and heavy. The skin is often passively congested, and hence prone to low forms of ulceration or eczema. When the gangrene commences as a result of some peripheral lesion, an area of painful redness is first noticed, perhaps running on to ulceration, and in the centre of this patch a slough forms, which becomes dry and black; the process gradually spreads from this focus with more or less inflammation, so that it is sometimes known as *inflammatory senile gangrene*. If, however, it results from thrombosis of the main vessels, death occurs without the supervention of local inflammatory phenomena, the toes merely shrivelling up and dying (*non-inflammatory senile gangrene*). The inner side of the great-toe (Plate II., Fig. 1) is perhaps the commonest situation for the mischief to start, and thence it spreads from one toe to another, and also along the instep and up the ankle to the leg. Pain is always a marked feature, whilst the extent of the gangrene is dependent partly on the amount of general and local vitality, and partly on the asepticity or not of the surrounding tissues. As the disease spreads, the patient becomes exhausted by the long-continued pain and want of sleep; and septic fever, bedsores, or the intervention of some cardiac, pulmonary, or renal complication, may also hasten a fatal termination.

Treatment.—In the earlier stages of malnutrition of a limb from a defective arterial supply, marked by coldness and a sense of weight and fatigue, much may be done to improve the vitality of the part by the cautious use of hot-air baths, massage, etc., and attention to the general health. The patient must be warned of the danger of small injuries, and the possible harm that may follow the injudicious use of hot-water bottles, or of incautiously cutting corns. If the condition progresses and actual gangrene is threatening, *arterio-venous anastomosis* may be justifiable. In this procedure the circulation is deflected from the obstructed arteries to the patent veins, and thereby the vitality of the limb may be preserved. Hunter's canal is the usual site of this operation. The vein and artery are exposed and divided transversely; the distal end of the artery and the proximal end of the vein are ligatured, and a careful end-to-end anastomosis is effected between the proximal end of the artery and the distal end of the vein.

When gangrene is actually present, treatment is governed by the observation that after any attempt to amputate through *neighbouring* living parts the gangrenous process is certain to commence again in the flaps; if merely cutting a corn suffices to originate the malady, much more will so severe an injury as an amputation. It is therefore necessary to amputate *well away from the dead mass* at a point where the blood-supply is sufficient to nourish the flaps, and yet not so near the trunk as to threaten life seriously through shock. This must be undertaken *early*, especially when pain is severe, or if a spreading cellulitis is present. In order to determine the most favourable site, the main artery should be carefully examined, and if feasible no operation is performed at a level where it appears to be occluded. It should also be remembered that the muscles are better supplied with blood than the overlying skin. The condition of the limb will therefore influence the surgeon's decision; if thin, attenuated, and shrivelled, it will be wise to amputate high. The operation should inflict as little damage as possible on the parts, the flaps being nearly equal in length and sufficiently thick to include plenty of muscle. Where the mischief is limited to the foot, it is usually advisable to amputate through the lower third of the thigh, or at any rate in the neighbourhood of the knee-joint, though not through the joint itself, as the flaps in that operation are always rather flimsy. If for any reason amputation is contra-indicated, the limb is kept aseptic (if possible), wrapped up warmly, and elevated. The general health is maintained by suitable nourishment, tonics, and stimulants, and pain alleviated by opium.

(*c*) **Gangrene from Arterial Thrombosis (non-senile)** is not a common occurrence. It arises as a result of the affection known as *endarteritis obliterans*, and also develops in the later stages of typhoid fever and other conditions of severe toxæmia as an outcome of arterial thrombosis, caused partly by the increased coagulability of the blood, partly by a localized endarteritis, lighted up by the circulating toxins. The femoral artery is most usually blocked, but occasionally the trouble will spread up to the aorta and involve both legs in the gangrenous process. Unless the vein is also involved, the gangrene is usually of the dry type. It is wise to wait until a line of demarcation has formed, and then amputate well above.

A similar condition is met with chiefly in Russian and Polish Jews who are heavy cigarette smokers, resulting from an affection which has been designated thrombo-angiitis obliterans (Leo Buerger), in which extensive thrombosis occurs first in the arteries and later in the veins of the leg. In the earlier stages various sensory and trophic changes are noticed, and in the later gangrene, usually of the dry type, occurs. It has been suggested that in early cases arteriovenous anastomosis between the femoral artery and vein might be useful.

A limited gangrene of the tips of one or more fingers of a dry type may occur as a consequence of the pressure of a cervical rib on the subclavian vessels.

A curious form of gangrene occasionally follows the application of a *carbolic acid* compress, even when weak solutions—*e.g.*, 1 in 60—are employed. The fingers are the parts usually affected, and the gangrene does not seem to be due to tight bandaging, or to the presence of a waterproof covering. Possibly the carbolic acid determined prolonged arterial spasm, and the anæmia was followed by local necrosis.

(*d*) **Diabetic Gangrene** is mainly due to the abnormal condition of the blood in diabetes, thereby reducing the power of the tissues to resist bacterial invasion; but it is also in measure the result of a sclerosing endarteritis and peripheral neuritis. It is not generally met with in the subjects of acute diabetes, nor in people under forty years of age. It results usually from some slight traumatic or infective injury, and often commences on the under side or at the extremity of one of the toes as a bleb, surrounded by a dusky purple areola. When the bleb is opened or bursts, the central portion of the underlying tissue is found to be necrotic, and from this focus the gangrene spreads. If the part is kept aseptic, and in limbs with some degree of endarteritis, the dead part may shrivel and dry up, especially when suitable dietetic restrictions are enforced; but if such local and general precautions are not observed, extensive suppurative infiltration of the soft parts may follow (Fig. 24), even though the necrotic process itself be of slight extent, and from this the patient may succumb, the fatal issue being due partly to diabetes, partly to toxæmia, and being often preceded by coma. Not uncommonly several foci of mischief develop, and the extent of subcutaneous involvement is sometimes much more extensive than the limited affection of the skin.

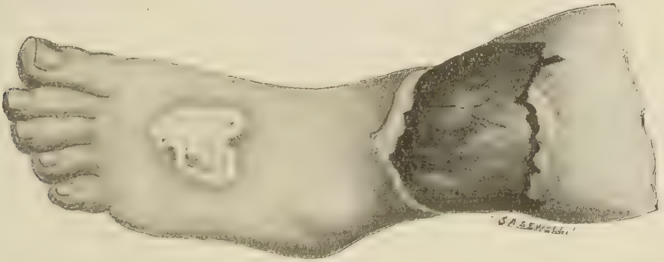

FIG. 24.—DIABETIC CELLULITIS AND GANGRENE OF FOOT AND LEG.

Treatment.—In the less severe cases, involving one or more toes, it will often suffice to keep the part warm and aseptic, until it is separated by natural processes, or at any rate the surgeon merely completes the work by dividing or dissecting out bones. Naturally, the elimination of sugar must be checked, if possible, by suitable diet and the administration of codeia. In more extensive trouble the character of the treatment turns largely on the amount of vascular disease and the degree of the accompanying inflammation. If the vessels are tolerably healthy, amputation not very much above the upper limit of the gangrene is justifiable; but if the main trunks are probably affected, a high amputation will be required, if the patient's general condition permits, although there is some risk that diabetic coma may supervene. When extensive suppuration is present, it is sometimes wise to lay the parts open for awhile and drain away the inflammatory exudations before considering the question of radical treatment. The choice of the anæsthetic will also require careful consideration; and spinal analgesia should be employed when the lower extremity is involved.

(*e*) **Raynaud's Disease,** or **Spontaneous Symmetrical Gangrene,** is a condition usually met with in anæmic or neurotic young women between the ages of fifteen and thirty. It is due to vaso-motor spasm, dependent on some deep unrecognised lesion of the spinal cord, or in some cases to a peripheral neuritis. Three stages are usually described: (i.) local syncope or anæmia, due to arterial spasm, and characterized by pallor and painfulness of the part; (ii.) local asphyxia or congestion, the affected tissues being blue and cyanosed from venous regurgitation; and (iii.) necrosis, the part becoming dry and black. The onset is often sudden, and the disease may last for a variable time, from days to months. If gangrene supervenes, the latter is the limit more often reached; but it by no means necessarily follows that tissue necrosis occurs in every case. The disease is usually symmetrical, and affects the fingers rather than the toes, but superficial patches may occur on any part of the body; the process is non-febrile and often very painful. Paroxysmal hæmoglobinuria has been observed, and is supposed to be due to vaso-motor disturbance of the kidneys. Ankylosis of the smaller interphalangeal joints and localized patches of anæsthesia, associated with neuralgic pain, are sometimes present, resulting from peripheral neuritis. The condition often resembles the later stages of a chilblain, but is distinguished by its more dusky colour, the greater pain, the absence of itching, and the fact that the process is not limited to exposed or terminal parts, or to cold weather.

The **Treatment** in the early stages is directed to the prevention of gangrene. Iron, quinine, and other suitable tonics are administered, and menstrual irregularities are attended to. Friction with stimulating embrocations, warm douches, and protection from cold and injury, may be employed locally, but probably the best results will follow the use of electricity. The constant current is employed, and preferably in the shape of the electric bath, local or general as required, and repeated either once or several times a day. When actual gangrene is present, the dead tissue should be kept aseptic, when sooner or later it will be absorbed or separated.

(*f*) **Gangrene from Ergot** is a rare phenomenon, but it has been known to occur when diseased rye has been used in the manufacture of bread. The resulting gangrene may vary in extent from the loss of one or two fingers or toes to the sacrifice of the greater portion of one or more limbs.

II. Traumatic Gangrene.

By traumatic gangrene is meant the loss of vitality of some part of the body as the consequence of an injury, whether applied to the main bloodvessels (*indirect* traumatic gangrene), or directly to the tissues (*direct* traumatic gangrene).

(*a*) **Indirect Traumatic Gangrene** arises from a considerable variety of lesions, and the course and clinical history are similarly variable.

(i.) **Ligature of the main artery** does not produce gangrene in a healthy limb; but should it be in a state of chronic malnutrition and anæmia from preceding arterial disease, death of a certain portion may ensue, the case running a similar course to one of gangrene due to embolus. It is usually of the dry type, and limited to one or two toes, or to a patch of the superficial tissues; but if it reaches the more fleshy portions, the moist variety supervenes.

Treatment consists in keeping the parts warm and aseptic until a definite line of separation forms, and then in assisting the natural processes at this spot by dividing tendons and bones. If, however, a considerable area of the limb loses its vitality, and especially if the dead tissue is moist and putrid, an early high amputation is required.

(ii.) **Arterial thrombosis from injury** only causes gangrene under special circumstances, the course and treatment being similar to that resulting from an embolus.

(iii.) **Obstruction to both main artery and vein** is an almost certain precursor of gangrene, if it occurs suddenly. Cases are on record in which both vessels have been ligatured, or even portions of them removed without such a result, as in dealing with cancerous deposits in the axilla or in the extirpation of aneurisms; but in both these instances obstruction to the circulation must have previously existed, necessitating the opening up of collateral anastomotic branches. In a normal limb the simultaneous occlusion of both afferent and efferent trunks, as by inclusion in a ligature, is almost certain to determine tissue necrosis. It is also caused by the *strangulation* of organs, either within the body, as in a strangulated hernia, or outside of it, as when a ligature is tied round the base of the penis, or a bandage applied too tightly round a fractured limb. It may even result from the swelling of a limb under a bandage which has been originally applied with no undue tension.

Gangrene may also follow the rupture of a main artery and compression of the accompanying vein by the extravasated blood, an occurrence perhaps most frequently seen after *fractures* and *dislocations ;* it is then always of the moist type. (See Chapter XX.)

Treatment varies considerably in these cases. If the parts are hopelessly injured, amputation should be performed at once, so as to prevent the risk of infection. In some fractures and dislocations with vascular lesions, it may be possible to save the limb by cutting down, turning out clots, and securing the injured vessels, whilst the bony lesion is dealt with in a suitable manner. The limb should afterwards be elevated slightly, and the peripheral segment kept warm and aseptic. Should gangrene supervene, amputation will be required, its situation depending on the character of the local lesion; if it is not of a serious nature—*e.g.*, a clean fracture or simple dislocation—it is wise to wait for a line of demarcation; but if comminution of bone or other grave local trouble is present, one should amputate above the injury.

(*b*) **Direct Traumatic Gangrene,** or that resulting from the immediate effect of injury to the parts, is similarly due to a variety of lesions.

(i.) **Severe crushes or blows** are a common cause of this type of gangrene; thus a limb may become mangled between the wheels of machinery, or by heavy weights falling on it, or by the passage of vehicles over it. Not only are the parts crushed, severely contused, or even 'pulped,' but the bloodvessels may be torn, and the pressure of extravasated blood contributes to the result. The gangrene is of the moist type, and is more likely to supervene in patients whose vitality is diminished. Thus, a crush of the foot in an elderly person is often followed by it, when in a young and healthy adult it could be prevented.

Treatment.—If the part is hopelessly damaged, operation should not be delayed, on account of the dangers of infection; and therefore immediate amputation is recommended. The question of shock and its influence in determining operation is discussed elsewhere. When there seems a reasonable chance of saving the limb, it is cleansed and purified under the strictest antiseptic precautions; should gangrene supervene, it may be removed later.

(ii.) **Prolonged pressure** is also capable of producing gangrene. Gangrene from *splint pressure* is either almost unavoidable, or the result of carelessness. When the fragments are much displaced after a fracture, considerable pressure may be required to retain them in good position, and then in spite of every precaution necrosis may ensue. Pain of a neuralgic type is usually complained of for a few days, but even that is not necessarily severe enough to attract much attention; when the limb is freed later on, the dead portion of the skin is white, anæmic, and insensitive. The necrotic process may extend to some depth, and hence the greatest care must be taken to keep the dead tissues aseptic, thereby avoiding grave local and constitutional disturbance.

Bedsores are likely to occur in patients who are kept for a long time in the recumbent posture, or in any one particular position. The parts most exposed to pressure become red and congested, and finally ulceration or actual gangrene supervenes. Bedsores are not usually extensive or deep; but if the patient is debilitated or paralyzed, the process may extend rapidly, destroying fasciæ, laying open muscular sheaths, and even leading to necrosis or caries of bone (*acute bedsore*). The spinal canal itself has been opened in this way, and death from infective meningitis has resulted. To prevent the occurrence of such sores, the nurse must see that the draw-sheet and bed-linen are placed smoothly and without creases, and that no contamination by urine or fæces is allowed. The skin of the back is daily washed with some unirritating soap, and rubbed with a soothing, strengthening, and hardening application, such as methylated spirit, or a mixture of brandy and white of egg. It is then dusted over with a powder, consisting of equal parts of oxide of zinc, boric acid, and starch, in order to harden and dry it. If the skin becomes red, it should be painted with a mixture of equal parts of tincture of catechu and liquor plumbi subacetatis, which when dry leaves a powdery film on the surface, and protected from pressure by a circular hollow water-pillow. Paraplegic patients or old people should be placed on a water-bed, which must be sufficiently, but not excessively, distended. If there is too little water, the weight of the body displaces it to one side, and no good results; whilst if there is too much, the bed becomes hard and resistant, and fails in the object for which it is employed. When an open sore forms, fomentations are required in the more acute stages, whilst later it may be dressed either with diluted boric acid ointment, or in the more sluggish cases with resin and boric acid ointments mixed. Friar's balsam, mixed with castor-oil (1 part of the balsam to 7 of the oil), is useful in this condition.

(iii.) The action of **corrosive or caustic chemicals** is followed by a localized traumatic necrosis, the degree of which varies with the amount and character of the irritant present, and the duration of its action. All that is needed is to keep the parts aseptic, and allow them to be absorbed or separated by natural processes.

III. Specific or Infective Gangrene.

(*a*) **Acute Spreading, Acute Emphysematous, or Spreading Traumatic Gangrene.**—This disease is one of the most rapidly fatal and serious met with in surgery.

Causes.—(i.) The *individual* attacked is often debilitated as a result of vicious or careless living, heavy drinking, or simple malnutrition; but even healthy individuals may be attacked if the virus is active. It is sometimes seen in diabetics, but a form of glycosuria occasionally develops in the course of the disease.

(ii.) The causative *lesion* is usually severe, such as a compound fracture or dislocation, especially if the soft parts are much contused or very dirty. Defective purification of such tissues, and injudicious attempts to save them by accurate and close stitching, perhaps without drainage, are amongst the most frequent causes of an outbreak of this disease. Less frequently it follows a small and insignificant prick, scratch, or abrasion, through which a virulent organism gains access to the tissues. In this way post-mortem porters, nurses, or pathological demonstrators may become infected.

(iii.) An organism frequently present is the *Bacillus œdematis maligni,* which is identical with the *Vibrion septique* of Pasteur and the French writers. It is a rod-shaped organism, which closely resembles that of anthrax, but is Gram-negative, and has a greater tendency to grow into long threads. It is actively motile, and forms oval spores, which may be placed at the centre or at the end of the rod. Cultures only develop under anaërobic conditions; and if the culture medium contains glucose, a large amount of foul-smelling gas is produced. Mice and guinea-pigs die within twenty-four hours of inoculation; locally a spreading œdema is produced, the connective-tissue spaces being distended with fluid containing bacilli, and perhaps gas; bacilli are also found in the exudations which occur in the serous cavities, in the connective tissues of important organs, and in the blood for some time after death. The *B. aerogenes capsulatus* may also cause acute spreading gangrene. It is an anaërobe with a similar power of fermenting sugar, but is non-motile, rarely forms spores, and is Gram-positive. It usually possesses a well-defined capsule, but this is not invariable. Careful investigation of fifty-eight cases* of spreading gangrene demonstrated that in only fourteen cases was there a pure infection, with an anaërobic organism, which was more frequently the *B. aerogenes capsulatus* than the *B. œdematis maligni.* A special feature of infection with the former is the large amount of gas produced, not only in the tissues, but also post-mortem in the vessels, and notably in the liver, from which it can easily be squeezed, constituting the 'foaming liver' of some writers.

Symptoms.—The outbreak of this disease may be delayed for two or three days, during which the wound is perhaps a little painful, but shows no special signs of activity; none the less, mischief is going on out of sight, and the absence of discharge is a bad sign. In some cases the period of incubation is shorter. Suddenly and perhaps with little warning the case develops as a hyperacute cellulitis, accompanied by general septicæmia. The wound, when opened up, is found to be unhealthy, the surface covered with sloughs, and a thin serous or sero-purulent discharge escaping. The inflammatory process rapidly spreads along the connective-tissue planes of the limb, which becomes swollen, painful, and brawny; in one case the gangrene spread from the foot to the groin within twelve hours. At first the parts are occupied by a bright red blush, but they soon become purple, gangrenous, and crepitant. The emphysema spreads widely and rapidly, with at first no other local evidence of mischief; sloughing will, however, follow if the patient live long enough. Evidences of profound toxic disturbance, such as hyperpyrexia and delirium, soon manifest themselves; but not uncommonly fever may be entirely absent, the temperature being subnormal and coma present. The outlook is exceedingly grave, death usually ensuing in two or three days.

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* See Corner and Singer on 'Emphysematous Gangrene,' *Trans. Path. Soc. Lond.*, vol. lii., 1901, p. 42; Welch's 'Shattuck Lecture,' *Philadelphia Med. Journ.*, August 4, 1900.

Treatment.—It is impossible to emphasize too strongly the danger of closing up completely and without drainage lacerated and contused wounds which have been caused by accidents on the railways or in the street, whereby the damaged tissues have been brought into contact with the ground, and perhaps infected thereby. Dangerous anaërobic organisms are so constantly present in the soil, that to close up such a wound is to favour their development. Scrupulous antiseptic cleansing of the wound, and especially by the use of oxidizing agents, such as peroxide of hydrogen, sanitas, etc., loose suturing of the parts, and free drainage, are essential if dangerous consequences are to be avoided. The appearance of inflammatory phenomena will necessitate free opening of the wound, followed by incisions through infected tissues and immersion of the limb in a warm bath containing Condy's fluid or sanitas. If, in spite of this, the disease spreads, a high amputation, well above its upper limits, even through the shoulder or hip-joint, is the only hope of saving life.

(*b*) **Wound Phagedena and Hospital Gangrene** were seen often enough in the pre-antiseptic era, but are now practically unknown. They consisted in a rapidly spreading ulceration or gangrene, which attacked operation wounds a few days after their infliction, and as a rule led to rapid death.

(*c*) **Cancrum Oris and Noma.**—**Cancrum oris** is an infective gangrenous stomatitis, affecting young children living in squalid surroundings in over-populated districts of large cities. The patients are always in a low state of health, and frequently convalescing from one of the exanthemata, particularly measles. The process starts in an abrasion of the mucous membrane, which, being infected from a diseased or dirty tooth, becomes inflamed and gangrenous. A foul ashy-gray pultaceous slough forms on the inside of one of the cheeks, and from this a most offensive discharge is poured into the mouth and swallowed, the breath in consequence becoming intensely fœtid. The gangrene gradually spreads both superficially and deeply; the cheek becomes swollen, shiny, and tense, and, should the process extend through its whole substance, a black slough appears on its outer aspect. In bad cases, the adjacent bones of the face may be affected and die, and the tongue, palate, and even the fauces, may also be involved.

The general phenomena are those of a severe toxæmia, since not only are the toxic products swallowed, but they are also absorbed by the lymphatics, and may be inhaled, in the latter case giving rise to septic pneumonia. Moreover, the patient runs a considerable risk of developing pyæmia, from implication of the facial or other veins in the necrotic process, whilst infective septicæmia may also supervene. Rigors and high fever may occur early in the case, but death is usually preceded by symptoms of collapse and coma, with a subnormal temperature.

The **bacteriology** of this affection is a little doubtful, but it is probably due to the *Streptococcus pyogenes* in conjunction with one or more of the bacteria always present in a dirty mouth, and notably the spirillum of Vincent's angina.

The **Treatment** must be prompt and energetic if the child's life is to be saved. The patient should be anæsthetized, and all the pultaceous slough removed by cutting or scraping, until healthy bleeding tissue is reached. The denuded surface is then freely rubbed over with pure carbolic or strong nitric acid. In using such agents, the throat must be carefully protected, and the excess of acid in the case of the former dissolved by spirit, and in the latter neutralized by bicarbonate of soda. If the bones of the face are involved, they must be removed, as also any offending teeth. Afterwards the mouth is to be washed out frequently with antiseptic lotions, such as a solution of peroxide of hydrogen (1 in 10), sanitas (1 in 10), boroglyceride (1 in 20), or permanganate of potash. The child must be given plenty of suitable fluid nourishment, and, if need be, stimulants. In the most severe cases, the whole thickness of the cheek may be encroached on; loss of substance must be made good by subsequent plastic work. Necessarily, the cicatrization following this destructive process results in a good deal of permanent impairment to the movements of the jaw.

Noma is the name given to a similar process occurring about the genital organs of children, especially the vulva. The **Treatment** is practically the same, except that here it is possible to immerse the patient in a warm bath, after having removed the infected tissues.

(*d*) For **Carbuncle** and **Boil,** see Chapter XVII.

IV. Gangrene from Thermal Causes.

1. **Frost-bite.**—This condition is not often seen in this country, but is by no means uncommon in regions where the winter is colder, and is induced more readily if a high wind is blowing, the heat of the body being thereby more quickly dispersed. Children and old people are more likely to be attacked, as their vital powers are less marked than in adults. It originates in one of two ways:

(*a*) *From the direct effect of cold on the tissues,* which become shrunken, hard, and of a dull waxy appearance. No pain is experienced in the freezing process, so that onlookers are more likely to recognise the condition than the individual himself. The extremities of the body, where the circulation is a little sluggish, and exposed parts, such as the nose and ears, are chiefly liable to be attacked. Gradually the part shrivels, turns black, and is either absorbed or separated by a process of ulceration, with or without suppuration. A feature of gangrene from frost-bite is the more extensive implication of the superficial tissues on account of their greater exposure.

(*b*) *From the subsequent inflammation* in parts which, though frozen, are not immediately killed. The thawing of these structures is accompanied by severe pain, and the prolonged anæmia so depresses the vitality of the vessel walls that the re-admission of the circulating blood is likely to be followed by an acute inflammation, which terminates in necrosis from compression of the vessels by the rapidly-formed exudation. If it escapes actual death, the part remains red, congested, and painful for some time, and superficial ulcers may even develop; eventually, however, it recovers.

Treatment.—The frozen parts must be thawed very gradually, and the blood admitted into the tissues slowly, if inflammatory gangrene is to be avoided. They should be gently rubbed with snow or cold water, and warmed by being held in the hands of the manipulator, whilst the patient should be placed in a cool room, the temperature of which is slowly raised. As reaction comes on, a small amount of warm drink may be cautiously given. Excessive pain or congestive œdema may be limited by elevation of the part. If actual gangrene occurs, the dead tissue must be rendered and kept aseptic, and the case carefully watched until a definite line of separation has formed.

Indians, lumbermen, prospectors, etc., in North-West Canada, where frost-bites are common, have found that oil of turpentine is the best application in all stages. The parts are kept soaked with the fluid, and the results are reported as phenomenal.

2. **Burns and Scalds.**—These may be considered as a special variety of wound, not necessarily ending in gangrene, brought about by the action of heat; burns, either by the close proximity to, or direct contact with, flame or heated solid bodies; scalds, by the action of boiling water, superheated steam, or other hot fluids or gases, the difference in the effects being comparable to the distinction between roasting and boiling. Naturally, fluids such as oil, which boil at a higher temperature than water, produce increasingly severe results.

Six different degrees of burn were described by Dupuytren, and his classification may still be retained with advantage. The *first degree* consists merely in a scorch or superficial congestion of the skin, without destruction of tissue; the part may, however, remain red, painful, and prone to ulceration for a time. Should the scorch be often repeated, as by people constantly warming their legs before the fire, the skin becomes chronically pigmented and indurated (*erythema ab igne*). In the *second degree* the cuticle is raised from the cutis, and a bleb or blister results. When this bursts, and the cuticle is removed, the cutis vera, red and painful, is exposed below. Permanent discoloration may follow this lesion. In the *third degree* the cuticle is destroyed, as is also part of the cutis vera, but the tips of the interpapillary processes, including the exquisitely sensitive nerve terminals, are laid bare and left intact; consequently this is a most painful form of burn. The deeper structures of the skin—viz., the sweat and sebaceous glands, and the hair follicles—remain untouched, so that, although the surface during the healing process becomes covered with granulations, the integument is very rapidly replaced, since there are so many epithelial elements from which it can grow. The cuticle is able to form not from the edge only, as must occur wherever the whole of the cutaneous envelope is destroyed, but also from innumerable foci scattered over the wound surface. The resulting scar, though often white and visible, undergoes no contraction: it is supple and elastic from containing all the elements of the true skin. In the *fourth degree* the whole thickness of the integument is destroyed, as well as part of the subcutaneous tissues. In the *fifth* the muscles are also encroached upon, whilst in the *sixth* the whole limb is charred and disorganized. In the last three forms healing can only occur by removal of sloughs and the formation of a cicatrix, which by its contraction may lead to deformity.

The **Local History** of a burn may be described in three stages, corresponding to the three stages through which an ulcer or a lacerated wound passes: (1) The stage of destruction or burning, the various degrees of which have been just alluded to; (2) the stage of inflammation and sloughing, whereby the dead tissue is removed, and the wound converted into a healthy granulating sore; (3) the stage of repair. There are no special characteristics of these processes which call for particular note, except that they are usually associated with infection, unless the burn is a small one. The skin is generally dirty (from a surgical standpoint) at the time of the accident; it may be infected from the clothes which are being worn, and immediate attention may be impossible. Moreover, the extent of the lesion and the terrible pain caused by it often render complete sterilization impracticable.

The **General or Constitutional Conditions** which correspond to these three stages require a little fuller notice.

1. In the early stages *shock* is usually present, and its intensity depends as much on the extent of the burn as on its depth, so that total charring of a limb may cause less depression of the system than an extensive superficial scorch, especially if the latter involves the abdomen or the head and neck. It frequently passes into a condition of collapse, due in measure to the absorption of toxic products from the burnt tissues.

2. Subsequently a period of *inflammatory fever*, usually of infective origin, follows, and may last four to fourteen days. The viscera become congested, particularly the gastro-intestinal canal, liver, lungs, and brain, and various complications may result therefrom.

One of the most interesting sequelæ, though at the present day it is admittedly uncommon, is *Ulceration of the Duodenum*. The ulcer is of the usual duodenal type, and occurs close to the orifice of the bile-duct. It probably results from the elimination by the liver of some irritating substance derived from septic changes in the burnt tissues which is capable of inducing thrombosis, or of producing ulceration. In one case under observation, a post-mortem examination revealed a patch of well-marked ecchymosis in the duodenal mucosa exactly opposite the orifice of the bile-duct. Obviously it was the early stage of this condition, and would have gone on to ulceration had the patient lived. For clinical phenomena, see Chapter XXXV.

3. When healthy repair is occurring locally, and the parts are kept aseptic, no abnormal constitutional condition should be present, although there may be a certain amount of *asthenia* or anæmia. Where, however, the wounds are septic and suppurating freely, this tendency will be much more marked, and the patient may even develop hectic fever and amyloid changes in the viscera, and finally die of exhaustion.

Causes of Death from Burns.—If an individual is burnt to death, the fatal event is usually occasioned by asphyxia from the smoke and noxious fumes of the fire; shock and syncope from fright may perhaps be adjuvants, especially if the heart is weak or diseased. Within the first few days death results from shock or collapse from toxæmia; in the second stage, from infection, internal complications, ulceration of the duodenum, etc.; in the third stage, from exhaustion or intercurrent maladies. The prognosis in children is always more unfavourable than in adults.

Treatment.—In superficial scorches without vesication, all that is needed is to protect the affected parts, *e.g.*, by dusting them over with boric acid powder mixed with starch, or by painting them with collodion. Blisters, when present, should be washed antiseptically and then punctured, so as to allow the contained serum, which always contains bacteria, to escape; the separated epidermis should then be cut away, and a picric acid dressing applied, when the burnt area is not too extensive; a piece of sterilized gauze or lint is soaked in a sterilized solution of picric acid (2 grains to 1 ounce), and applied to the burnt surface, and over this a pad of sterilized wool. Thus a dry dressing is produced, which may be left *in situ* for some days, when it is reapplied. The results are usually most satisfactory.

Where the burn includes deeper structures, the clothes must be removed with as little dragging as possible, being cut away if necessary; the damaged tissues are then bathed with some antiseptic, such as sublimate lotion (1 in 2,000), and covered up as rapidly as possible with sterilized lint or gauze soaked in eucalyptus-oil or weak carbolized oil (1 in 40). In some cases, where the skin and surface are exceedingly dirty, it is well to anæsthetize the patient, cut away parts which must obviously slough, and purify thoroughly the wound, which is covered with protective and dressed with cyanide gauze or some such material. In very extensive burns caution must be exercised in the use of poisonous antiseptics, such as carbolic acid or corrosive sublimate, or serious toxic effects may be produced.

If the patient is in a state of shock, he should be put to bed and covered with warm blankets or rugs, whilst perhaps a little warm stimulating fluid is administered, and a dose of morphia given hypodermically; in bad cases an intravenous injection of hot saline solution is advisable, and it may often be repeated with advantage. In the case of children with very extensive burns, it is sometimes useful to put them into a hot bath, to which some eucalyptus-oil, if obtainable, or Condy's fluid, has been added; the clothes are then removed or cut away, and the patient allowed to remain for some time, or until the shock has subsided, in the warm water, which should be replenished, if necessary. It may be desirable to repeat the immersion at every dressing. The wounds are then dressed, and the little patient removed to bed, where special attention must be directed towards maintaining the bodily heat, as, *e.g.*, by placing electric lights under the blankets which cover a cradle placed over the patient.

When a limb has been hopelessly charred or burnt to the bone, it is useless to retain it, and early amputation through the nearest healthy tissues should be undertaken.

During the stage of inflammation and sloughing the only requisite is to keep the parts as free from infection as possible, assisting the natural processes of repair by warm moist applications, and snipping away sloughs as they loosen. Subsequently the wounds are treated on general principles. The granulations often become prominent, and stimulating applications, such as touching them with nitrate of silver, may be necessary. In large wounds, healing should be assisted by skin-grafting, according to Thiersch's method, in order to prevent the wound becoming chronic. A similar proceeding should be undertaken in burns which involve the flexures of joints, so as to avoid subsequent contractions.

PLATE III

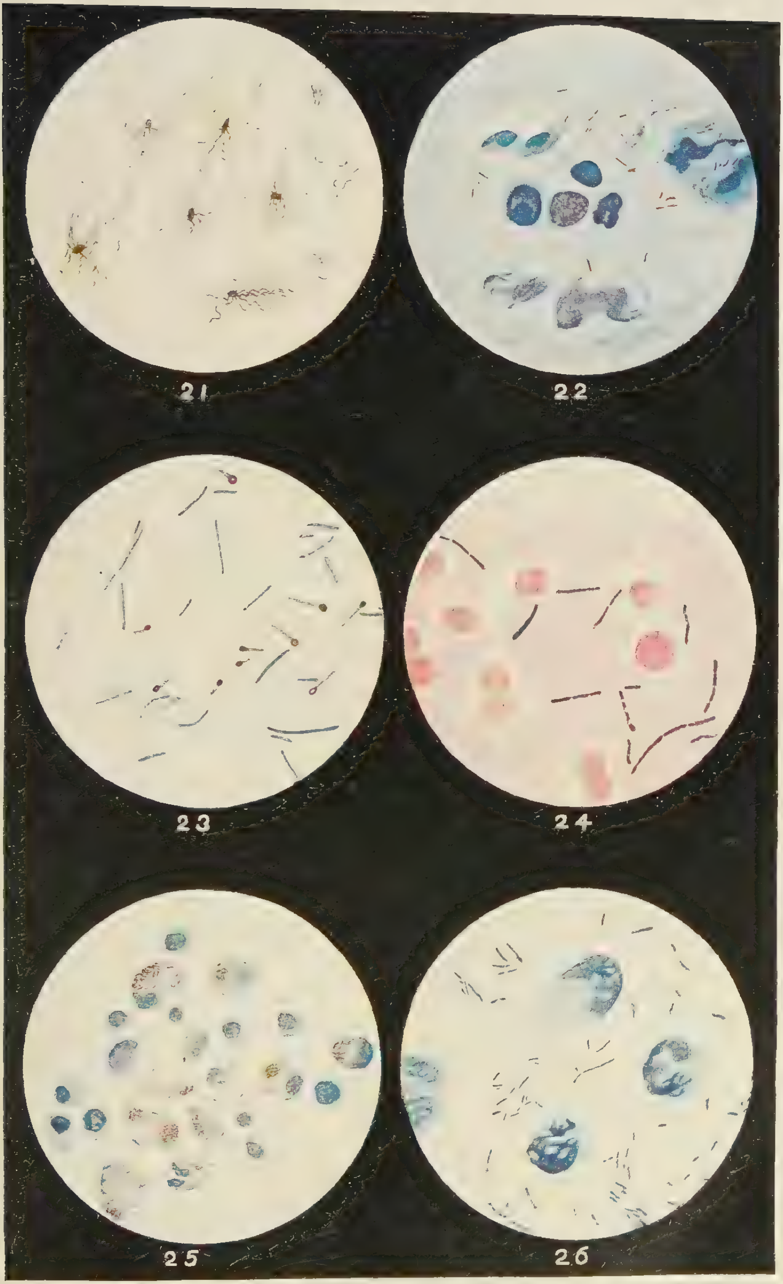

Fig. 21.—Typhoid bacilli, showing flagella. Van Ermengen's stain. *Fig.* 22. Tubercle bacilli in sputum. Carbol-fuchsin and methylene blue. *Fig.* 23.—Tetanus bacilli, some showing spores : from a culture. Stained by carbol-fuchsin and methylene blue. *Fig.* 24.—Anthrax bacilli in blood. Gram and eosin. *Fig.* 25 Leprosy bacilli, in cells from the spleen. Carbol-fuchsin and methylene blue *Fig.* 26.—Bacillus coli in urine, with a few pus cells. Methylene blue.

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CHAPTER VIII.

SPECIFIC INFECTIVE DISEASES.

Erysipelas.*

ERYSIPELAS is a contagious infective disease due to the development of the *Streptococcus pyogenes* in the smaller lymphatics of the skin and occasionally of mucous membranes, with a decided tendency to spread and to recovery without loss of tissue, the constitutional symptoms being due to the absorption of toxins developed locally. Occasionally the subcutaneous connective tissue is also involved, constituting the variety known as *cellulo-cutaneous erysipelas.*

There has been considerable discussion as to whether there is any difference between the erysipelas microbe and the ordinary *Streptococcus pyogenes* found in spreading suppuration, but it is now generally admitted that they are identical. The explanation of the differences in the clinical history and infectiousness between erysipelas and other conditions due to the development of *S. pyogenes* is probably to be found in the method of invasion and in the differing virulence of various strains of the organism, but the subject is not yet fully understood.

The **Causes** of erysipelas may be briefly stated as follows: (i.) The existence of an abrasion or wound in most cases, and particularly of an unprotected dirty wound. Thus, it is not uncommon to find it associated with neglected scalp wounds or with those communicating with the mouth. In the so-called *idiopathic* erysipelas the wound may be very minute, such as a prick or scratch, or there may be no obvious wound at all, infection occurring through a hair follicle in healthy skin. (ii.) A weak, depressed state of the constitution, as from alcoholism, deficient or bad food, vicious living, diabetes, albuminuria, etc. Some people, moreover, seem naturally predisposed to the disease, particularly plethoric and gouty individuals, and one attack renders the subject more liable to recurrence after a short period of immunity. (iii.) Bad hygienic surroundings are a most important additional factor in its production, especially overcrowding in hospitals and defective ventilation. But these are all merely predisposing conditions; the only exciting and absolute cause is—(iv.) infection with the particular micro-organism.

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* It is becoming more than ever doubtful whether erysipelas is to be looked on as a *specific* infection. Careful bacteriological examination is indicating that other pyogenic organisms than the streptococcus may be responsible for its appearance, and it is probable that hereafter we may have to relegate it to the chapter dealing with non-specific infections

The **Symptoms** of the disease are usually ushered in by a period of headache and malaise for about twenty-four hours. These symptoms are followed by a slight rigor, well-marked pyrexia, and the development of the rash, spreading either from the margin of the wound, or showing itself in apparently unbroken skin in the so-called idiopathic variety. If there is a wound, it usually presents a yellowish, unhealthy-looking surface, with very little evidence of repair. In an unmixed infection the healing process may continue until the rash appears on the third or fourth day, when the young cicatrix will break open again, exposing a dry and sluggish surface with a thickened margin. The *rash* is generally of a characteristic vivid rosy-red colour, disappearing on pressure, and accompanied by a sensation of stiffness or burning, scarcely amounting to pain, except when dense structures, such as the scalp, are involved, and then the pain may be severe. Swelling is not marked, except in lax areolar tissues, such as in the scrotum or eyelids; the œdema may then attain considerable proportions. The rash continues to advance more or less rapidly, with a continuous slightly raised margin, and as it spreads to new regions it fades away from those already involved, leaving a slight brownish stain and a fine branny desquamation. In some cases it does not spread regularly, but appears to leap over an interval, and then the intervening lymphatics are found to be thickened. Vesicles and bullæ form superficially, containing serum, which speedily becomes turbid, but suppuration is uncommon, except in lax œdematous tissue, such as the eyelids. Occasionally, from the severity of the inflammation or the low state of vitality of the tissues, the skin may become gangrenous and slough, especially about the umbilicus and genitals of young children. Neighbouring lymphatic glands are always enlarged and painful, and this may even be noted at a period when the rash has not appeared. Periphlebitis may also be caused, leading to pyæmic complications. Fever is present as long as the rash persists, and merely shows slight diurnal variations. It is not uncommon for the temperature to rise to 104° F., but anything above that is of grave significance. At first the fever is of a sthenic type, the pulse full, and the delirium noisy and active; but later on the pulse becomes quick and weak, accompanied by low, muttering delirium and great prostration of the vital powers. Delirium is usually a well-marked feature in erysipelas of the scalp, but this is due to the general rather than to any local condition, unless meningitis supervenes. Leucocytosis is moderate in degree (15,000 to 20,000 leucocytes per cubic millimetre). The duration of the attack is most variable, lasting, as a rule, from one to three weeks, but relapses are not uncommon. The swelling of the part does not always clear up entirely, owing to persistent blocking of lymphatics; when repeated attacks occur, this swelling may become so great as to constitute a form of elephantiasis.

The so-called **Idiopathic Erysipelas** mainly affects the head, and occurs in predisposed individuals, often recurring about the same time of the year; pain and delirium are prominent symptoms, and the subcutaneous tissue of the face becomes so swollen that the features are almost unrecognisable. Large blebs form, and abscesses are not uncommon about the eyelids.

Cellulo-cutaneous Erysipelas is due to infection of the subcutaneous tissues as well as of the skin with the specific virus, and results in suppuration and sloughing both of the skin and subjacent cellular tissue. To the ordinary phenomena of erysipelas are added a diffuse infiltration of the subcutaneous tissues, brawny at first in type, but subsequently softening and becoming boggy, the skin finally giving way, and allowing exit to the pus and sloughs. The general symptoms are correspondingly severe, and pyæmia may supervene. As distinguishing features from ordinary erysipelas, it it stated that the margin of the redness is less defined, and that the lymphatic glands are less enlarged.

Erysipelas of the Scrotum, or, as it is sometimes termed, 'acute inflammatory œdema,' is characterized by the part becoming greatly distended by serum, but without any marked redness. Suppuration and sloughing are not unlikely to follow. It thus somewhat simulates the appearance produced by extravasation of urine, but is distinguished from it by the facts that micturition is usually not interfered with, and that the swelling is not limited in the same way as in the latter affection.

Pathological Anatomy.—On microscopic section of the affected skin, colonies of cocci arranged in chains will be found invading the lymphatics just beyond the spreading margin, whilst in the inflamed area there is a considerable excess of leucocytes, blocking the lymphatics, and evidently engaged in the destruction and removal of the cocci, since phagocytic inclusion of the organisms is frequently observable. The lymph glands will also be found enlarged and congested. Fatal cases merely show the ordinary post-mortem signs of death from a general toxæmia (p. 91).

Diagnosis.—There is not much difficulty in recognising a case of erysipelas, if the distinguishing features of the rash are remembered, viz., its method of extension by a broad, sharply-defined, slightly raised and infiltrated red margin, and its almost invariable association with superficial vesicles, perhaps visible only on examination with a lens, or with obvious pustules or bullæ. An *infected wound* with pent-up discharge closely simulates erysipelas; but the redness has not such an accurately defined margin and does not spread beyond the immediate neighbourhood of the wound; cutaneous vesicles are not usual in ordinary sepsis, whilst lymphatic enlargement is uncommon. A patch of *cellulitis* will also be distinguished by the same features.

Prognosis.—Erysipelas is not peculiarly dangerous in itself (Osler gives the death-rate as 7 per cent. in hospital patients), but may become so from the complications. The most important of these are inflammatory conditions of the brain, lungs, and other viscera, especially of the kidneys. Erysipelas is usually attended with danger to life in old people, drunkards, and infants, whose vital powers become rapidly exhausted. It is interesting and important to note that, after an attack has passed, wounds, even if previously chronic and sluggish, often manifest marvellous reparative power, provided no other complication is present. Chronic lupoid and syphilitic ulcers may also rapidly cicatrize, and even malignant sores, especially sarcomata, have been known to be cured.

Treatment.—Erysipelas is a notifiable disease under the Infectious Diseases Acts, 1889 and 1899, and the patient must be isolated or removed if possible from a surgical ward. If unfortunately this is impracticable, the patient must be placed as far away from others as possible, and especially from those with open wounds, which from their position (*e.g.*, the mouth) cannot be properly protected from infection. It is wise under these circumstances to put off all operations that can be safely postponed; the bed should be surrounded with sheets kept moist with carbolic lotion, and the floor around sprinkled with the same. Special nurses and dressers must be told off to attend to the case, which should never be dressed with ungloved hands.

Local Treatment is concerned with two chief objects, viz., to check the spread of the disease, and to cure the localized outbreak. (1) Anything that will determine a local accumulation of leucocytes in the skin beyond the spreading edge should be beneficial in checking its advance, and perhaps the best and simplest method of effecting this is by painting over the healthy skin with two or three coats of liniment of iodine (the tincture is not strong enough), and repeating this daily until the disease has disappeared. Kraske's plan of scarifying the skin all round at a distance of an inch or two from the spreading margin, the knife just going deep enough to draw blood, acts in a similar manner and is effective; but it is painful and requires an anæsthetic. (2) Where tension and pain are severe, fomentations containing opium or belladonna (*e.g.*, 1 ounce of laudanum to 1 pint of lotio plumbi) may be applied; but the best local applications are ichthyol or thiol, the latter being an artificial sulphur compound much resembling ichthyol, but without the objectionable smell. A 20 to 40 per cent. aqueous solution is painted over the affected area several times a day until the fever disappears; a subsidiary advantage of this treatment is that the stickiness of the preparation hinders the diffusion of the virus.

In *cellulo-cutaneous erysipelas* early and free incisions must be made to relieve tension, and, if possible, anticipate suppuration. The tissues, when incised, look gelatinous from the œdema present, and much fluid of a sero-purulent type will escape. Antiseptic fomentations should be employed after the incisions have been made, until granulations have developed.

Constitutional Treatment must be of a tonic and supporting character. Good food, easy of assimilation, and quinine, should be freely administered, whilst the tincture of the perchloride of iron in ½-drachm doses, repeated three or four times a day, is still looked on by many as a specific. The latter drug must be combined with salines or purgatives, so as to avoid constipation. *Antistreptococcic serum* (p. 27) should be employed as early as possible, 10 or 15 c.c. of the polyvalent serum being given subcutaneously as a dose, and repeated once or twice a day. The results, however, have not been as satisfactory as was originally expected.

Diphtheria.

Diphtheria is an infectious disease, characterized by a fibrinous exudation which is closely incorporated with the superficial layers of the tissues affected, and results in a peculiar form of toxæmia. It usually involves the mucous membranes, particularly those of the pharynx, larynx, and nasal cavities; occasionally it attacks open wounds, the skin, conjunctiva, and the genitals. It is due to the *Bacillus diphtheriæ* (or Klebs-Löffler bacillus), which is a non-motile organism about 3 μ in length. It grows on all ordinary culture media, but most readily in the presence of blood-serum. It is Gram-positive, and often stains unevenly.

The *laboratory diagnosis* of diphtheria depends chiefly on the recognition of the organism in the exudate and its cultivation. The process usually adopted is as follows: The outfit necessary consists of a culture-tube of blood-serum and a sterilized cotton-wool swab in a test-tube. If the throat is to be examined, the patient should be placed in a good light, and, if a child, securely held. The tongue being depressed, the cotton-wool swab is withdrawn from the test-tube, and gently rubbed over any visible membrane. The plug is then withdrawn from the culture-tube, and the swab lightly wiped over the surface of the blood-serum. The swab is then replaced in its tube, and both tubes plugged. The culture-tube is incubated at 37° C. for twelve hours, and then examined; if the Klebs-Löffler bacillus is present, a growth of small, opaque, white colonies, slightly raised above the surface, will appear. Direct films may also be made from the swab and stained. The operator must always be on his guard lest the patient cough pieces of membrane, etc., into his face during the operation.

The serious feature of an attack of diphtheria is the absorption of the diphtheria toxin, for the bacilli are almost always localized. The toxin is an exotoxin, and not only produces fever, but also has a marked action on motor nerves, thereby producing paralysis This is most often shown in the palatal, orbital, and ocular muscles, but may affect the muscles of the trunk and limbs. Cardiac weakness is common, and is partly due to degeneration of muscle, and partly to action on the vagus. The toxin has considerable poisonous effect on the kidneys, and albuminuria is common.

The character of pharyngeal and laryngeal diphtheria is treated of under their respective headings.

Treatment.—The most important point is the administration of antitoxin, in doses of from 4,000 to 50,000 units. The unit is the amount of antitoxin which, injected into a guinea-pig of 250 grammes weight, neutralizes 100 times the minimum lethal dose of toxin of standard strength. In addition, local antiseptics are useful, and in laryngeal cases, where dyspnœa occurs from obstruction of the larynx by membrane, tracheotomy or intubation may be necessary.

Tetanus.

Tetanus is a local infective disease, due to the *Bacillus tetani*, associated with a characteristic toxæmia. The bacilli or their spores are found to be very widely disseminated, and, indeed, are present in almost every sample of garden or field soil; they have been found in the grime on a working man's hand and on dirty surgical instruments. Great difficulty was experienced in isolating the bacillus, but at last Nicolaier and Kitasato succeeded, by heating the pus from an infected wound to a temperature of 80° C. for an hour, thereby destroying all the pyogenic organisms. It occurs in the form of delicate straight rods, which sometimes grow into long threads. It is a strict anaërobe, ceasing to grow if the smallest trace of oxygen is present, and is usually cultivated in an atmosphere of hydrogen or nitrogen; no gas is produced by its growth. It forms characteristic spores which are nearly spherical in shape and situated at the extreme end of the bacillus, giving it the appearance of a drumstick (Plate III., Fig. 27); these appear both in the pus of the wound and in cultures. It stains by Gram's method and possesses numerous flagella. The bacilli themselves are not powerful parasites, and when separated completely from their toxins often fail to cause infection, even when injected into susceptible animals; should, however, a minute trace of toxin be present, it so depresses the vitality of the surrounding tissues that the bacilli continue to grow and produce more toxin.

Ætiology.—The causative organism is a facultative saprophyte—*i.e.*, is capable of continuing its development apart from the body—and is almost constantly found in garden soil, stable refuse, and dust or dirt of any kind. Those, therefore, who are likely to be much brought in contact with the ground—*e.g.*, negroes and agricultural labourers—are specially liable to the disease, owing to their more constant exposure to infection. Horses, also, are peculiarly susceptible to tetanus, and the bacilli are usually present in their fæces; hence stablemen and others brought into contact with horses are attacked with comparative frequency. The disease is more frequently seen in the tropics than in other climates, probably owing to the heat favouring the development and virulence of the organisms in the soil.

The existence of a **wound** can almost always be demonstrated, and it is usually of a dirty, lacerated or punctured character, and suppuration is generally present. Any part of the body may be thus affected, but perhaps those regions, such as the sole of the foot or the palm of the hand, which are likely to be brought into contact with the soil, are most often involved. Serious street accidents, especially those due to tramcars and motor vehicles, are only too likely to be followed by tetanus. The depressed vitality of the tissues owing to the bruising and tearing, the irritation caused by the growth of pyogenic organisms, and the absorption by the latter of any oxygen present, thereby determining a condition of anaërobiosis, co-operate in favouring the development of the tetanus bacilli. Hence it is rare for the disease to affect wounds where asepsis has been maintained and rapid repair has been effected, and it is very uncommon, though possible, for it to develop after blows or bruises with no breach of surface. Gunshot wounds due to blank cartridges are often followed by it, since the injury is largely due to the wad, which is made of coarse horsehair felt, and is therefore likely to contain spores of the bacillus. Commercial gelatin, derived from the hoofs, etc., of horses, often contains the bacilli, and the injection of this substance in the treatment of aneurisms has been followed by this disease.

Pathology.—Tetanus forms the best example in pathology of a local infection with general toxæmia. The bacilli remain localized in the neighbourhood of the wound, and do not enter the blood or reach distant parts of the body. The toxins produced locally act on the cells of the central nervous system in a manner very similar to strychnine. There is, however, a very unusual feature in the mode of passage of the toxin from the local lesion to the brain and cord, in that it appears to travel in the nerves themselves, and not in the blood, as in other infections. One or two of the proofs that have been advanced in support of this theory may be quoted. Tetanus may be caused by the injection of a very small dose of toxin directly into a nerve, whereas the animal may resist the injection of four or five times this amount into a muscle; and if the nerve is cut between the site of inoculation and the central nervous system, the spasms may be delayed, or even prevented altogether. This may explain the beneficial effects which sometimes followed the now abandoned operation of nerve stretching or section in tetanus. Further, the toxin can be demonstrated in the nerves themselves, since they give rise to tetanus when introduced into a susceptible animal.

The post-mortem anatomical changes are not characteristic. The muscles are often pale, or show evidences of rupture or extravasation of blood. The peripheral nerves extending from the wound may be red and congested for some distance: this may not be due to the action of the toxin (which appears to produce no demonstrable lesions of the nerves themselves), but to pyogenic inflammation. The nerve-centres frequently present areas of softening and perivascular cellular exudation, with some hyperæmia, especially in the pons and medulla. Degenerative changes may also be evident in the ganglion cells of the cord.

Clinical History.—**Acute Tetanus** usually manifests itself in this country two or three weeks after infection, but sometimes abroad as early as a few hours or days. The causative wound is usually suppurating and looks unhealthy, but when infection is delayed it may be healed. The patient generally complains first of a difficulty in opening the mouth, associated with a cramp-like pain in the muscles of mastication and of the neck. This soon becomes so marked that it may be difficult even to insert a paper-knife between the teeth (*trismus*, or lock-jaw), causing great difficulty in the administration of food; to it is added a fixed and rigid condition of the muscles of the back of the neck and of the face, the latter producing a curious grin-like appearance (*risus sardonicus*), whilst *dysphagia* is sometimes caused by spasm of the pharyngeal muscles. A considerable degree of fever is often manifested, but in some cases an apyrexial course is maintained until nearly the end. The spasms soon extend to the trunk and extremities, accompanied by cramp-like pains, and when fully established they may be excessively painful and violent, and the remissions between them but partial. Fortunately, the disease usually involves the respiratory muscles late in the attack. The more severe spasms can be excited by any form of stimulus, such as the slamming of a door, a draught of cold air, or some voluntary movement, and are always of a tonic (*i.e.*, continuous) character. The body is contorted in various directions, and respiration may be much impeded by the fixation of the thorax. Occasionally the body is arched backwards (*opisthotonos*) by the contraction of the muscles of the back, the recti abdominis being firm and tense—' as hard as boards '; sometimes it is doubled forwards (*emprosthotonos*), and in rare cases laterally (*pleurosthotonos*). The muscles may contract so violently as to be ruptured, whilst teeth have been broken and the tongue has been almost bitten off. The intellectual faculties usually remain clear to the end, which is generally due to exhaustion from a repetition of the convulsions, or more rarely to asphyxia induced by a prolonged fixation of the respiratory muscles. Before death the temperature sometimes runs up to 108°, or even, in one case, to 112° F., and it often continues to rise for a degree or two after death; such hyperpyrexia is mainly due to the continuous muscular contractions. The surface of the body is bathed in sweat, and the urine is scanty, and occasionally albuminous. Death may occur in twenty-four hours from the onset of the disease, or not for four or five days.

Chronic Tetanus usually begins later after infection, is less severe in its symptoms, and more likely to be recovered from. The course is usually afebrile, and the spasmodic contractions may be limited to the wounded part of the body whence the infection has arisen, or may be general. Sometimes the patient lies in bed with his jaw partially fixed, and the muscles of his neck, back, and abdomen rigidly contracted, but with none of the characteristic convulsions.

A special and uncommon variety known as *cephalo-tetanus*, or *T. paralyticus* (German, *kopf-tetanus*), follows injuries within the area of distribution of the cranial nerves, and especially those about the supra-orbital margin. It is characterized by the association of trismus with facial paralysis on the affected side, and for a time this may constitute the whole picture, so that the patient may walk to see the doctor; but later on the usual tonic spasms occur in other parts of the body, and other cranial nerves may become paralyzed, especially the third, leading to strabismus. Spasm of the muscles of deglutition and attacks of maniacal frenzy are sometimes present, and hence the name *T. hydrophobicus* which has been applied to it.

Diagnosis.—In the early stages tetanus must be distinguished from simple *trismus* arising from dental irritation, or from inflammatory ankylosis of the temporo-maxillary joint. This may be readily accomplished by noting that rigidity of the neck muscles is also present in tetanus. *Strychnine-poisoning* leads to a very similar group of symptoms, but is recognised from tetanus by the contractions being more sudden and violent, the relaxation of the muscles between the spasms complete so that the mouth can readily be opened, whilst the hands are involved in the contractions, a rare sign in tetanus, and the muscles of mastication often escape.

No difficulty should be experienced in distinguishing tetanus from *hydrophobia*, owing to the very different nature of the convulsions in the latter case—*i.e.*, clonic and not tonic; moreover, they affect the muscles of respiration and deglutition, whilst the history of the case, the early hallucinations, and the absence of tonic muscular contractions, are also characteristic features.

Laboratory methods are usually unnecessary for the diagnosis of the disease when developed, but in case of doubt the best method is to collect some of the discharge from the deeper portions of the wound, dilute it with broth, and divide it into two parts: one of these is to be injected into a mouse or guinea-pig, whilst the other portion is mixed with 1 c.c. of tetanus antitoxin and then injected into another animal. If the former animal develops tetanic symptoms, whilst the latter escapes, the diagnosis is assured.

The **Prognosis** is unfavourable in any case, but the longer it lasts, and the lower the temperature, the more likely is the patient to recover, whilst an acute onset, hyperpyrexia, sleeplessness, delirium, and strabismus are bad signs. The length of the incubation period is also a most important factor; for even when antitoxin is administered, the mortality in cases with an incubation period of less than ten days is at least 20 per cent. higher than when the appearance of the disease is delayed to a later period.

Treatment.—In places where tetanus is known to be rife, it is a wise precaution to administer antitetanic serum as a *preventive* or immunizing agent in cases of wounds or abrasions that might possibly be infected, especially if due to street accidents, or if suspicious bacilli are found on microscopic examination of a scraping from the deeper parts of the wound. The dose need not be large (1-5 c.c.).

After the disease has appeared, the originating sore, if accessible, should be freely excised and the wound cauterized, or the limb may be amputated; but even then convulsions may persist for a time, or prove fatal, from the amount of toxin already in the system.

In addition to these local measures, the specific antitetanic serum, prepared from the blood-serum of an immunized animal, should be injected (p. 27). The serum is purely antitoxic, and has no effect upon the development of the bacilli, for the destruction of which local phagocytosis or other immunizing action has to be relied on. Any toxin circulating in the blood is readily destroyed or neutralized; but inasmuch as the toxin travels by the nerves and rapidly unites with the protoplasm of the nerve-centres, and then cannot be influenced by the antitoxin, the results of its use are often disappointing. The treatment should always commence with a large dose, and smaller amounts should then be administered once or twice a day, varying with the severity of the symptoms; 20 to 30 c.c. may be given as the initial subcutaneous injection, followed by doses of 10 to 15 c.c. twice a day. It is better, however, to introduce somewhat smaller doses into the veins, or into the subdural space after lumbar puncture. Intracerebral injections have been discontinued owing to the risks associated therewith, but there is no objection to ' blocking ' the passage of toxins up the main nerves in early cases by injecting them with antitoxin. Another plan of treatment, suggested by Baccelli, consists in the hypodermic injection of carbolic acid; 10 or 15 minims of a 2 per cent. solution are injected two or three times a day, and although its action cannot be explained, yet the percentage mortality of cases treated in this way hitherto reported is certainly less than that accompanying the serum treatment.

The patient should be kept absolutely quiet in a darkened room, and free from all sources of irritation. The spasms may be diminished or almost abolished by the injection, either subcutaneously or by lumbar puncture, of a sterilized solution of magnesium sulphate, which acts solely by reducing the excitability of the motor cells, and has no action on the tetano-toxin, fixed or free. The dose subcutaneously is 10 to 20 c.c. of a 10 per cent. solution every four hours; whilst intraspinally 2 to 4 c.c. of a 25 per cent. solution can be injected daily without ill-effect. Chloroform may be administered with the same object. Opium, chloral hydrate, bromide of potash, physostigma, and curare, have been vaunted as beneficial drugs, but probably cases which have recovered after their exhibition would have done so without. Food should be nutritious, fluid, and unstimulating; it has been suggested to feed the patient twice a day by a stomach-pump under chloroform, or by a soft rubber catheter through the nose, but rectal feeding can be tolerated just as well, and, indeed, the patient must be given an abundance of normal saline solution by this route in order to help in the elimination of toxins and relieve his thirst.

Hydrophobia.

Hydrophobia is an acute general infective disease, transmitted from animals to men, especially from rabid dogs, cats, wolves, etc. It consists in an affection of the central nervous system, and one of its most marked features is the long and variable incubation period. It never originates idiopathically either in animals or man, infection usually following a bite; but if the teeth pass first through a garment, the virus may be wiped off, and the individual may escape. It has also been proved that if an infected animal merely licks an abraded surface the disease may be transmitted, even when the animal has not at the time shown any of the more typical signs of rabies.

In the **Dog**, rabies manifests itself three to five weeks after infection, but the period varies considerably; the original wound usually heals perfectly, or there may be some inflammatory thickening about it. The disease commences with a stage of depression, which is manifested by snappishness and irritability, especially towards other animals, by restlessness, and by the dog moping in dark corners, with a depraved appetite, eating any kind of rubbish or dirt, and even its own excreta. This period lasts for two or three days, and is perhaps the most dangerous, since there is nothing very suggestive about the symptoms. It is usually followed by a stage of paralysis, going on to death. During the whole attack the mouth is filled with ropy saliva, which the animal vainly tries to scratch away; the bark loses its ring and becomes hoarse, and as the disease progresses the lower jaw becomes paralyzed; finally, after partial or general convulsions, the animal dies five or six days from the onset. In a few cases a stage of maniacal frenzy occurs, when the animal runs 'amok' and bites anything and everything that comes in its way.

In **Man** the incubation period is most variable, lasting from days to months or years, but as a rule it does not exceed six weeks. During this interval the wound heals, although the scar may remain tender and neuralgic. The disease is ushered in by a vague sense of terror, with illusions of the senses and disturbance of the mind, lasting for about twenty-four hours. Restlessness, sleeplessness, loss of appetite, and a repugnance to fluids follow, with perhaps some slight febrile disturbance. The more characteristic symptoms are inaugurated by a convulsive stiffness of the tongue, neck, and especially of the muscles of deglutition and respiration, which becomes more marked if any attempt is made to swallow. The typical convulsions are clonic in character, and thus differ from those of tetanus; they become more and more generalized, being brought on after a time by almost any afferent impulse, however slight—such as a blast of cold air, a flash of light, a sudden noise, especially such as is caused by the movements of fluids; swallowing is quite impracticable. The mouth is usually filled with ropy mucus, which is very difficult to remove. The respirations become catchy, and a loud hiccoughing noise may be produced by spasm of the diaphragm, which is sometimes thought to resemble the barking of a dog. Finally, the convulsions may entirely cease, and the patient dies, retaining his consciousness to the end, the fatal issue being due to the destructive changes taking place in the medulla, or to exhaustion; it may, however, occur earlier, from spasm of the glottis. The disease lasts about a week, but may be more rapid, killing even in two days.

The **Post-mortem Changes** are mainly negative. Evidences of acute inflammation of the lower part of the medulla, including the centres for the 9th, 10th, and 11th nerves, are observed on microscopic examination, the vessels being thrombosed, and the connective tissue infiltrated with leucocytes. The nerve fibres and ganglion cells may also be found degenerated. The salivary glands are always somewhat enlarged. The disease may be diagnosed in the lower animals by the recognition of the Negri bodies in the hippocampus major and cerebral cortex. They are minute cell-like bodies, consisting of a large or small central mass, or of a cluster of minute corpuscles, surrounded by a homogeneous hyaline zone, around which there is a delicate membrane. These are found in nearly all cases of the disease, and are thought to represent a stage in the life-history of a protozoal parasite. They can be demonstrated in a few hours, and afford a means of detecting the presence of rabies in a dog without waiting for the results of inoculation experiments. They have also been found in man, and have been cultivated by Noguchi.

Preventive Measures should be adopted *immediately* in all cases of bites from dogs which are either rabid or may possibly become so. The circulation in the limb should be arrested by a string or bandage, bleeding encouraged, and some powerful caustic, *e.g.*, pure carbolic acid, applied as soon as possible. A free excision of the part is, however, preferable.

Pasteur's Preventive Inoculation is based on the discovery that the injection of an attenuated virus in increasing doses, and in gradually increasing strength, protects an animal or individual from the disease, and will even catch up the poison already inoculated, and save the patient from its subsequent development, if too long a start has not been given. The method employed is as follows: A virus of constant and maximum intensity is first obtained by passing the poison from a dog through a series of rabbits, until the animal dies with regularity on the seventh day, all parts of the cord being then equally virulent. The material inoculated is obtained by mashing up a portion of the spinal cord or medulla of the diseased dog in sterilized broth, and injecting it with a hypodermic syringe beneath the arachnoid after trephining. All that is now needed is to take a series of these virulent cords, and dry them by hanging in a glass bell-jar with some caustic potash at the bottom for variable periods, the virus being thus weakened in its intensity, until at the end of fourteen days it is completely destroyed. Individuals are inoculated with portions of such cords, pounded up in sterilized broth, beginning with the weakest, and gradually increasing the strength of the injection, until a preparation of a cord which has merely hung one day is used. This method of treatment was introduced in 1885, and the results hitherto obtained have been such as to indicate that we have here a most potent preventive agent against hydrophobia, granted that the disease has not been allowed too long a start. When the disease has attacked an individual, only **palliative treatment** can be adopted. Every source of irritation and disturbance must be removed, and the patient kept absolutely quiet. With a view to diminish the spasms, chloral may be administered internally, or chloroform inhaled, or cocaine sprayed on the fauces. All the nourishment that the patient can possibly take should be administered, and preferably by rectum.

Anthrax.

This disease results from infection with the *Bacillus anthracis*, which produces in sheep, cattle, and other animals the so-called 'splenic fever,' characterized by well-marked fever and enlargement of the spleen. In man, if the microbe is inoculated through the skin, it produces a local inflammatory swelling, known as a 'malignant pustule,' or a more diffuse condition termed 'anthrax œdema'; sometimes the latter follows the former. If the virus is absorbed by the lungs or intestinal canal, it originates a general inflammatory disorder, known as 'woolsorter's disease,' or anthracæmia.

The *B. anthracis* (Plate III., Fig. 28) is one of the largest of the pathogenic organisms, measuring 5 to 20 μ in length, and 1 to 1·50 μ in breadth. It is found in the blood of diseased animals in the form of rods or threads, composed of a variable number of individual elements (from two to ten). It is aërobic, immobile, grows best at about blood-heat, and liquefies gelatin. Well-marked spores are formed within the bacillus when cultivated artificially and in the presence of oxygen; but spore-formation has not been observed in the living tissues. The bacilli are readily killed by boiling for a few seconds, whilst the decomposition of the carcass in which they are present causes their death in about a week. The spores, however, are very resistant; for whilst a 1 per cent. solution of carbolic acid kills the bacilli in two minutes, the spores remain alive after a week's immersion. Moreover, alcohol and even a 5 per cent. solution of carbolic acid have no effect on them, unless acting for a long time. If a mouse is inoculated, say, at the root of the tail with a needle, the point of which has been dipped in the blood of an animal which died of splenic fever, it succumbs in less than twenty-four hours, and bacilli are found in nearly every organ of the body.

Some animals are immune against the attacks of anthrax, especially the dog and rat; and one of Pasteur's most useful discoveries was that of providing artificial immunity for cattle and sheep by inoculating them with an attenuated virus, obtained by exposing a cultivation for some time to a high temperature.

Symptoms.—Infection with this organism usually occurs amongst graziers who tend the living animal, or butchers who deal with the carcass; it is also met with amongst workers in hides or wool.

Malignant Pustule is usually seen on the face or forearm, and commences as an angry red pimple at the site of inoculation, which rapidly spreads, with much infiltration of the base, whilst the centre becomes covered with vesicles, the serum within which becomes blood-stained or dark brown in colour, and contains the typical bacilli. This stage is associated with no pain, but only with great itching and irritation. As the pustule extends, the centre becomes gray, and finally black, constituting an eschar or slough, whilst around it upon an area of deep brawny congestion and œdema is a narrow ring of vesicles. The process gradually becomes more marked locally, whilst the lymphatic glands and vessels are also enlarged and involved in the disease. Generally, there is a certain amount of fever and malaise, which does not become pronounced until about the fourth or fifth day. The temperature then rises to 102° or 103° F., the pulse becomes rapid and irregular, and gastric irritability, vomiting, and flatulence more marked. Should the disease progress unchecked, the surrounding parts are involved in a rapidly spreading œdema; thus from the face it may extend to the neck, chest, and back. The respirations become shallow and embarrassed, whilst signs of grave constitutional mischief, such as delirium or coma, manifest themselves, and the unfortunate individual rapidly succumbs, generally in less than a week from the onset, but sometimes in thirty to forty hours. More commonly the case runs a more favourable course, limiting itself to the local manifestations, which gradually clear up, the slough separating and the œdema disappearing. Of course, should there be more than one focus of mischief, the prognosis is much worse.

Anthrax œdema runs a rapidly fatal course; it is usually seen about the face and eyelids, the skin becoming red and brawny, as in erysipelas, and after a time covered with vesicles, whilst finally gangrenous patches appear. The lymphatic trunks and glands are also involved.

The condition may be mistaken in the localized form for accidental vaccination or a staphylococcic infection, but is recognised by the presence of the bacilli in the serum of the vesicles; in cases of doubt cultures should be made.

Woolsorter's Disease (or anthracæmia) is the term applied to the general condition resulting from the development of these bacilli in the body without any external lesion. The virus gains access to the system by either swallowing or inhaling the dried spores. If they enter the respiratory tract, the patient complains of fever and malaise for a few days, followed by the development of a sero-fibrinous pleuro-pneumonia, the exudation containing large numbers of bacilli. This runs a rapid course, with high fever, great dyspnœa, impairment of the circulation, and finally collapse in a great majority of the cases. If the bacilli enter the stomach, they are usually destroyed by the acid chyme; but should any of them or their spores reach the intestine, the alkaline contents form a suitable breeding-ground, and the walls of the gut are soon attacked and the disease becomes general. Colic, cramps, vomiting, and blood-stained diarrhœa are the most marked features in such a case. The intestinal type appears to be not quite so virulent or fatal as the pulmonary, but is decidedly worse than the cutaneous.

Treatment.—In the cutaneous affection, excision of the necrotic patch and of all the infiltrated tissues around, and the application of the actual cautery or of pure carbolic acid, used to be recommended, though those who have had much experience of the affection think such treatment of little value, and trust in fomentations for the localized variety.

Several sera (p. 28) have been introduced for the treatment of anthrax, and good results have been obtained, especially in the localized forms of the disease. Sclavo's is most used; it is obtained by immunizing asses or goats with Pasteur's vaccine (p. 15), followed by injection of large doses of virulent cultures. The dose is 20-40 c.c. (340-680 minims), repeated in twenty-four hours, if necessary; in severe cases the first dose may be injected intravenously. Sobenheim's serum is prepared in a different way, and also gives good results; the dose is the same. The use of either serum may be followed by fever and sweating, and improvement is often very rapid. They appear to stimulate phagocytosis.

Gonorrhœa.

Gonorrhœa is an infective process due to the action of a specific micro-organism, the Gonococcus or *Diplococcus gonorrhœæ* (Plate I., Fig. 3), and characterized (in its commonest form) by a discharge of pus from the urethra. The organism is a diplococcus, and each coccus of the pair is usually kidney- or bean-shaped, and the two lie with their concave borders facing one another. Single cocci and tetrads sometimes occur. It is not easily cultivated, and hæmoglobin is necessary for its growth; the simplest method of preparing a suitable culture medium is to spread some sterile blood on the surface of ordinary agar. The colonies are small and translucent, appearing like droplets of dew. Such cultures set up gonorrhœa when injected into the human urethra, thus proving the causal relation of the organism to the disease, as all of Koch's postulates are fulfilled. The lower animals are all immune. The gonococcus does not stain by Gram's method; this fact is of great importance in diagnosis, since most of the diplococci with which it might be confounded retain the stain. It occurs in large quantities in the pus from a gonorrhœal lesion, and in most cases it is found within the polynuclear leucocytes. This is very characteristic, as also the fact that, whilst most of the cells are usually free from organisms, those that are invaded by cocci contain them in abundance (see Plate I., Fig. 3, in which some of the cells are free from germs, but in others the diplococci can be seen clustered round the polymorphous nuclei). The pus also contained desquamated epithelial cells, in or on which many cocci may often be seen.

The *laboratory diagnosis* of gonorrhœa does not usually involve cultural methods, but can be made by an examination of stained pus-films. The best way is to stain by Gram's method, and to counterstain by dilute carbol-fuchsin. In this way the gonococci will be coloured red, whilst most of the other cocci with which they could be confounded are deep violet. The intracellular distribution of the cocci and the freedom of most of the pus-cells, whilst others are packed full of organisms, are points of great diagnostic value. Sometimes, however, most of the gonococci are extracellular.

In the male the primary lesion is an acute catarrhal inflammation of the anterior portion of the urethra, which quickly runs on to suppuration, and is likely to spread back towards the deeper portions of the urethra, or even to the prostate, bladder, or epididymis. These lesions usually constitute the whole of the disease, but in some cases the gonococci enter the blood-stream and affect distant organs. The joints are most frequently affected, but occasionally typical pyæmic phenomena supervene (gonococcæmia), with secondary abscesses and even ulcerative endocarditis.

The Symptoms of Acute Gonorrhœal Urethritis (male) usually commence within a few days of the infection, varying from two to eight. Most commonly the discharge appears about the third or fourth day, being preceded by itching of the meatus and a scalding pain on passing urine. The lips of the meatus are congested and swollen, and the discharge, which is at first thin and mucoid, soon becomes thick, abundant, and yellow in colour. This stage lasts for a variable time, and is sometimes associated with a good deal of dragging pain in the back and loins, together with some constitutional disturbance and fever. The bowels are usually constipated, and the appetite impaired. Occasionally the swelling and congestion of the mucous membrane are so great as to lead to retention of urine or hæmorrhage from the urethra. The first attack is always more serious than subsequent ones, although it is often more amenable to treatment. Gouty and rheumatic people are especially difficult to treat, and relapses frequently occur after the discharge has apparently ceased; it is said that fair people suffer more than those who are dark.

If suitable treatment is adopted, the discharge entirely ceases at the end of two or three weeks; but if neglected, or sometimes in spite of treatment, the inflammation spreads backwards, giving rise to what is usually termed a **Posterior Urethritis,** since it involves that portion of the canal which lies behind the deep constrictor. It generally becomes evident about the end of the second week, and is characterized by frequent and painful micturition, a sense of pain and heaviness in the perineum, possibly a little blood in the urine, and a general feeling of depression. This extension backwards is always serious, since it is likely to be followed by complications involving the prostate, testis, or seminal vesicles, whilst it is an extremely common cause of **Chronic Gonorrhœa** or **Gleet,** in which a more or less abundant discharge continues for some time without any other troublesome symptom than occasional scalding on passing urine. The discharge is often thin and muco-purulent, and may be so slight as merely to cause the lips of the meatus to stick together, or may only be evident on squeezing the urethra after a night's rest. This may last for a long time, even years, and it must be remembered that even in this stage the disease can be transmitted to women. Gleet is sometimes due to an ulcerated or granular condition of some portion of the mucous membrane; the discharge is then yellow, and the urethra is tender on the passage of a sound; the presence of the ulcer or granular patch can be recognised by the urethroscope. In other cases gleet arises from chronic prostatitis, a condition not uncommonly associated with chronic enlargement of the vesiculæ seminales. The latter condition may be recognised on rectal examination, whilst, when the prostate is involved, flocculi of mucus in the shape of worm-like threads may be detected in the urine, especially after massage of the gland by the finger introduced into the rectum.

When the disease has lasted for a considerable time, or after repeated attacks, a certain amount of peri-urethral infiltration is certain to follow, and a stricture of the urethra may result: this may also be due to the cicatrization of the ulcerated and granular patches in the urethral wall, alluded to above.

A *routine examination of the urine* in cases of gonorrhœa will often throw much light on the course and extent of the disease. In the acute stage 4 or 5 ounces are passed into one glass, and the remainder into a second; if the anterior urethra is alone involved, the discharge will be swept out in the first few ounces, and the urine in the first glass is alone turbid, containing threads or small flakes of pus. Involvement of the posterior urethra causes the urine in the second glass to be nearly as turbid as that in the first, and the co-existence of cystitis would make it even more turbid. In the *chronic* state, when merely a gleet is present, it is essential to wash out the anterior urethra with 5 or 6 ounces of boric acid solution, which are retained for examination, and then the urine is passed into two glasses, as suggested above. Unless this preliminary irrigation is undertaken, the stream of urine may wash out the discharge from the posterior urethra and invalidate the test. Examination by the *urethroscope* or *endoscope* is also necessary in cases of gleet. The instrument consists of a metal tube fitted with electric illumination in such a way as to render visible the walls of the urethra, which are advisably distended with air by a bellows. A commencing stricture can be easily recognised, as also ulcerated areas, patches of granulations more or less polypoid, etc., whilst suitable local treatment can also be undertaken.

Every purulent discharge is not necessarily gonorrhœal, since a simple urethritis may follow connection with a woman who is simply suffering from leucorrhœa, or has scarcely recovered from her menstrual period, but with no suspicion of a venereal taint. In these cases infection may be due to ordinary pyogenic cocci, or possibly to the *B. coli communis*, which is known to be not an unfrequent cause of vulvo-vaginitis. A diagnosis of simple urethritis may be suggested by the history, but only a microscopical examination of the pus, and a demonstration of the absence of gonococci, can establish it with certainty. It must be remembered, however, that gonococci are capable of remaining in a latent or passive state for a very long time in the folds or crypts of a mucous membrane, and hence a person who has once suffered from it may be capable of transmitting the disease, although no obvious evidence of its existence is present. Moreover, a highly acid condition of the urine in a gouty patient, especially if loaded with uric acid crystals, may light up into activity a urethritis which has been quiescent for some time. The practitioner is not unfrequently consulted as to the advisability of marriage after an attack of gonorrhœa; the cessation of the discharge is not sufficient to warrant such a step. The only safe test is to light up a fresh attack of urethritis by the injection of some chemical irritant—*e.g.*, a solution of nitrate of silver (1 in 100)—and to examine the discharge bacteriologically for the presence or not of gonococci.

In the **Treatment** of the early stages of acute gonorrhœa it is essential to keep the urine free from acidity by the use of alkalies, to maintain a free action of the bowels, and to allay the irritability of the parts by sedatives, such as tincture of henbane. The diet should be light and unstimulating, and all alcoholic drinks prohibited, as also strong tea and coffee, whilst the patient should be recommended to drink plenty of bland fluids, such as barley-water or milk and soda-water. The scrotum should be supported in a suspender, and the patient advised against taking severe or prolonged exercise. No local treatment is necessary, although the use of hot hip-baths may relieve the pain and irritation; indeed, at this period injections are harmful. The same treatment must be adopted as long as the discharge is copious and the scalding continues. As soon as these symptoms moderate, oleo-balsams in the form of oil of sandal-wood (10 minims, in capsules, three to six times a day), copaiba (10 minims, in capsules or mixture, thrice daily), or cubebs (½ to 1 drachm doses, wrapped in wafer-paper), may be advantageously employed. Both cubebs and copaiba, especially the latter, are capable of producing a bright red erythematous rash which causes much irritation, and may be extensively diffused over the body.

The value of *injections* in the treatment of the disease has been much discussed, and is a point on which difference of opinion exists. On the whole, we are inclined to think that many of the less severe cases of acute gonorrhœa can be successfully treated without them, and that they should not generally be employed when marked local irritation or scalding is present; but when the discharge persists, or the urethra has become thickened by previous attacks, and especially in gleet, their use is imperative. To employ them with advantage, the following plan should be adopted: The urethra is first washed out, so as to remove any discharge from it; for this purpose the normal act of micturition answers admirably, so that the injection should be used immediately after passing water. The rounded nozzle of a small glass syringe, containing about half an ounce, is inserted into the meatus, the lips of which are compressed over it. The fluid is thrown into the urethra, and held there for about twenty seconds by compressing the orifice with the finger and thumb, as the syringe is withdrawn; then, on relaxing the pressure, the fluid escapes. Other forms of syringe, on the principle of the indiarubber bottle, etc., are recommended, but the glass is unquestionably the cleanest. Of the many injections employed, one of the best consists of a mixture of tincture of catechu (10 minims to 1 ounce of water) and sulphate of zinc (2 grains to 1 ounce), but solutions of permanganate of zinc (¼ grain to 1 ounce), or nitrate of silver (¼ grain to 1 ounce), or protargol (1 per cent.), are also very effective. The great secret consists in using the injection four or five times a day at first, and afterwards night and morning, even after all visible signs of the discharge have ceased. The fluid should always be at a temperature of 100° F., and care taken not to use too strong a solution.

One is bound to admit, however, that many genito-urinary surgeons hold views very different to these, and, indeed, maintain that gonorrhœa can be aborted, or, at any rate, rapidly brought under control at any stage by large injections of a weak solution of permanganate of potash, introduced with sufficient force to distend the urethra in all its parts and enter the bladder; all the crypts and lacunæ are thus reached by the antiseptic.

The Treatment of Gleet is always a matter of difficulty. The general habits of the patient must be attended to, as in the acute stage, whilst the bowels must be opened, and absolute sexual continence enjoined to prevent the spread of the infection. Large doses of the liq. ferri perchlor., combined with a sufficient amount of Epsom salts to guard against constipation, may be given. Local treatment is generally necessary in the shape of injections as already described, and the passage of a cold solid metal bougie every three or four days has sometimes an excellent effect. Methodical dilatation of the urethra is also advised so as to compress all the crypts and lacunæ, and remove pent-up secretion. Massage of the prostate and vesiculæ *per rectum*, once or twice a week, is also advisable when these parts are affected. Patches of granular urethritis must be treated topically by applications of nitrate of silver (beginning with a solution of 1 in 1,000) through the endoscope. Should these measures fail, direct treatment of the posterior urethra by such reagents as solutions of nitrate of silver (1 in 1,000), or permanganate of potash (1 in 1,000), must be undertaken; perhaps the simplest method of effecting this is to pass a measured length of a rubber catheter into the urethra (about 7½ inches), and then inject the fluid; this must be undertaken two or three times a week.

Vaccine Treatment in Gonorrhœa and its complications has been proved to be of considerable value, though not so much for the treatment of the urethral discharge as for that of the complications. However, in some cases of a chronic gleet, or in the subacute stage when the discharge is slackening off, it may sometimes be used with advantage. In the gonorrhœal affections of joints, of the eye, or of internal organs, vaccines are most useful. The vaccine is prepared as described on p. 26, and the usual dose is from 100,000,000 to 500,000,000 dead gonococci.

Complications of Gonorrhœa.—These may be conveniently arranged under the following headings:

I. **Complications due to Direct Extension.**—*In the male*, the following may be described:

Balanitis is of frequent occurrence in patients with long foreskins, and is ordinarily due to pyogenic organisms, and not to gonococci. As a secondary result, inflammation of the lymphatics of the penis and inguinal bubo may follow. Sometimes this inflammation results in the development of red papillomatous outgrowths, known as *gonorrhœal warts*, which are found mainly on the glans penis, but occasionally on the preputial margin (Chapter XLI.).

Lacunar Abscess arises from infection of one or more of the lacunæ with the gonococcus or accompanying pyogenic organisms. A tense painful swelling forms along the floor of the urethra, which may project into the passage and discharge either into the urethra, or externally, or both; in the latter case a *penile fistula* will result. The abscess should be opened as early as possible from without, so as to prevent the latter occurrence, which is often very difficult to treat. If a fistula forms within a short distance of the meatus—a common situation—it seldom heals of itself, but may in some cases be closed by an application of the electric cautery or a weak solution of nitrate of silver. If, however, it remains intractable, the fistula should be laid open into the meatus. When it occurs in the body of the penis, a plastic operation is usually required; it consists in paring the edges and dissecting up the skin on either side so as to bring it together in the median line.

Chordee results from inflammatory infiltration of the corpus spongiosum or one of the corpora cavernosa, so that the penis, when erect, is bent downwards or to one side. It is exceedingly painful, and most marked at night when the patient becomes warm in bed. It is best prevented by the use of bromide of potassium or other sedative at bedtime, and when present may be treated by cold applications.

Inflammation of Cowper's Glands may in some cases give rise to deep suppuration in the perineum, and unless treated early by incision may lead to a urinary fistula.

Inflammatory conditions involving the prostate, seminal vesicles, epididymis, and bladder, and caused by gonorrhœa, are discussed elsewhere.

II. **Complications arising from Direct Transmission of the Virus.**—**Gonorrhœal Proctitis** sometimes results in the female from infection by the discharge which escapes from the vulva, whilst in both sexes it may be due to unnatural practices. It is characterized by tenesmus and a thick muco-purulent discharge, and is treated by injecting lotions of acetate of lead and opium, or of boric acid.

Gonorrhœal Rhinitis has also been seen in a few cases. It leads to an abundant discharge of pus, and should be treated by warm soothing injections, followed after a time by dilute astringents.

Gonorrhœal Conjunctivitis occurs either in adults, when it is unilateral to start with, or in infants, when it is bilateral, and due to infection during transit through the maternal passages (*ophthalmia neonatorum*). It is a remarkable fact that, although gonorrhœa is so very prevalent, such a small proportion of the patients suffer from conjunctival infection; it would appear, therefore, that not only must there be direct contact with the gonorrhœal poison, but in addition the mucous membrane must be in a receptive state. In the adult variety it is ushered in by redness and irritability of the eye, followed quickly by a discharge which is at first mucous, but soon becomes purulent. The eyelids are red and swollen, the conjunctiva is thickened and œdematous (chemosis), and the discharge liable to accumulate within the conjunctival sac. If allowed to progress unchecked, ulceration or even necrosis of the cornea may ensue, and possibly general panophthalmitis. This is pre-eminently the commonest cause of blindness in children. The first detail in the **Treatment** consists in protecting the opposite eye by means of what is known as Buller's shield; a watch-glass is fixed in a piece of mackintosh over the eye, and kept in position by plaster. The affected conjunctiva must be unremittingly attended to night and day, so as to prevent accumulation of discharge; it is frequently irrigated with warm boric acid lotion, and every four hours after washing out with this, the membrane is dried and gently irrigated with a solution of nitrate of silver (5 grains to 1 ounce), followed by sterilized salt solution. Between the applications lint wrung out of iced boric acid lotion is kept over the eye. This plan of treatment is continued until the suppuration ceases, and then the silver salt is omitted, and simple astringents, such as chloride or sulphate of zinc, are substituted.

In *infants* the disease often runs a rapid and severe course, and is very likely to lead to ulceration or sloughing of the cornea, a complication not uncommonly followed by escape of the lens and blindness. Credé's preventive treatment should always be adopted for new-born childern, viz., washing out the conjunctival sac with a weak solution of nitrate of silver (2 per cent.) or corrosive sublimate soon after birth. When suppuration occurs, the treatment to be adopted is practically identical with that detailed above, except that it is useless to attempt to limit the trouble to one eye.

III. **Complications resulting from General Absorption.**—**Gonorrhœal Affections of Joints** are not uncommon sequelæ, arising usually in the subacute stage of the disease. For clinical features and treatment, see Chapter XXIII.

Gonorrhœal Fibrositis.—Any muscular, tendinous, ligamentous, or aponeurotic tissues may become inflamed and painful during the course of an attack of gonorrhœa. Involvement of the ligaments supporting the arch of the foot is important, since, if the patient is still allowed to walk, the arch may be lost, and a permanent flat-foot result.

Gonorrhœal Sclerotitis, or inflammation of the deep subconjunctival fibrous tissue, is a rare affection, arising quite independently of gonorrhœal conjunctivitis. It is characterized by marked subconjunctival redness, the globe of the eye becoming distinctly tender. Local applications of atropine are required, and, if need be, leeches to the temples.

The pathology of the complications described in the last two paragraphs is uncertain. They are probably due to the presence in the tissues of a small number of gonococci of enfeebled virulence, or may be caused by toxins absorbed from the local lesion.

A true **Gonorrhœal Pyæmia** (gonococcæmia) occasionally develops, characterized by a formation of secondary abscesses in various parts of the body, containing only the gonococcus. They usually commence deeply, and at first are somewhat chronic, but subsequently the ordinary phenomena of suppuration supervene. They must be laid freely open, and as a rule heal satisfactorily, if slowly.

Occasionally the cardiac valves become infected and inflamed, and an ulcerative endocarditis due to gonococci has been observed. More rarely a true septicæmic invasion has destroyed the patient by a generalized development of gonococci in the blood.

Gonorrhœa in Women is by no means uncommon, even apart from prostitutes, in whom it is more or less constant; it is often overlooked or unrecognised, and is a frequent source of uterine and pelvic trouble. This is probably due to the fact that an uncured gleet in a man is not looked on as a bar to marriage. Occasionally the disease is contracted from the infected seat of a public water-closet, or from the use of infected towels, garments, etc.

The primary lesion is usually either in the urethra or in the cervical endometrium, or in both. Vulvitis is by no means uncommon, but in the adult a gonorrhœal vaginitis is unusual. Sometimes discharges from the cervix accumulate in the vagina and undergo septic changes, producing a simple vaginitis by the direct action of the bacterial toxins, but the gonococci do not attack the vaginal mucosa. In children a true vulvo-vaginitis occurs.

The *symptoms* in acute cases are those of heat and burning about the genitalia, combined with a purulent discharge and painful micturition. The urethra can be seen and felt to be swollen, and its orifice is red and congested; on pressing it, pus escapes. If the cervix is involved, the uterus becomes congested and painful; severe backache is noticed, and perhaps some tenderness on hypogastric pressure, with a blood-stained discharge. In the more chronic cases nothing may be noted except that the periods are painful, and that there is a certain amount of leucorrhœa, with occasional attacks of discomfort and frequency in micturition.

In all cases the inflammation is likely to spread, either to the bladder, or up the uterus to the Fallopian tubes (salpingitis), ovaries, or peritoneum. In the latter case the inflammation may be localized, producing adhesions around the fimbriated extremities of the tubes, and these are often an important cause of sterility. Occasionally a more generalized peritonitis results (*q.v.*).

Treatment consists in the use of frequent mild antiseptic douches (*e.g.*, lysol, 1 in 2,000), and in measures directed towards the urethra or cervix. When there is much urethral swelling and discharge, the diet is regulated and alkalies ordered, as for men; balsams may be useful, and even injections. In the later stages the shortness of the urethra permits topical applications of nitrate of silver to be made readily, and it is unusual for the inflammation to persist for long. In gonorrhœal endocervicitis the parts should be thoroughly cleansed by douching, and then a 10 per cent. solution of nitrate of silver applied through a speculum.

Soft Chancre (*Ulcus Molle*).

A **Soft Chancre** is a local infective disorder, which is rarely seen elsewhere than on the genital organs, and is almost invariably the result of impure connection. It is due to a specific bacillus, which was first described by Ducrey, and occurs in the form of short chains consisting of extremely slender rods, which do not form spores or stain by Gram's method. The organism has been cultivated, though with difficulty, and there appears to be no doubt as to its causal relation to the disease, though ordinary pyogenic organisms are often present as well. If artificially inoculated, a typical series of events follows. A red papule appears in twenty-four hours, whilst in two or three days a vesicle, surrounded by a zone of angry hyperæmia, is seen. The serum within the vesicle soon becomes turbid, and by the fourth or fifth day a fully-developed pustule is present; as soon as the cuticle is lost, an ulcer forms with cleanly-cut edges and a sharp, distinct outline. The chancre gradually increases in size up to a certain limit, and then if kept clean heals in about three weeks. Such sores may be met with on any part of the penis, but more especially on the prepuce and glans, or on the corona glandis, and are very painful and tender. The secretion is highly infective, and if inoculated elsewhere on the patient produces a typical sore, showing that the condition is purely local, and that no constitutional immunity results from its presence. The discharge from a true syphilitic chancre may produce a localized pustule on auto-inoculation, but no typical sore. Frequently several soft sores are present at the same time, and the discharge from one chancre is very likely to produce a similar affection (' satellite ' chancre) on any cutaneous or mucous surface brought into contact with it; *e.g.*, it may spread from prepuce to glans, or *vice versâ*, or from one lip of the vulva to the other. It is a curious but well-authenticated fact that soft chancres are rarely seen on any part of the body other than the genital organs.

Various **Modifications** of the typical chancre are seen, usually resulting from neglect or carelessness on the part of the patient. Thus, if a long foreskin is present, the discharge may be retained behind it, and extensive ulceration occur, which may even result in the glans protruding through the upper part of the prepuce, which drops beneath it. If the frænum is involved, hæmorrhage may supervene from ulceration into a branch of the artery found in that structure. When there is much inflammation, the base of the sore becomes indurated and infiltrated, somewhat resembling the Hunterian chancre. Not unfrequently syphilitic infection occurs at the same time as a soft chancre is contracted, or subsequently; the sore then runs a longer course, does not heal, even if kept clean, and after a time the patient presents the characteristic signs of syphilis.

In all cases the neighbouring **Lymphatic Glands** become enlarged and tender, and the process is very liable to terminate in suppuration, constituting a bubo. Two forms of this affection are described: (*a*) The *simple* or sympathetic *bubo* results from the absorption of ordinary pyogenic organisms from the abraded surface. The pus in this case, if inoculated elsewhere, may produce a pustule, but not a true chancre. The process is usually limited to the interior of the lymphatic glands. (*b*) The *virulent bubo* is due to the absorption, not only of pyogenic organisms, but also of the specific virus, so that the pus, if inoculated, always produces a typical soft sore. In these cases suppuration occurs not only within, but even more abundantly around the lymphatic glands (*periadenitis*), so that the skin becomes considerably undermined, and the wound produced by opening the abscess may take on the form of a large soft chancre in the groin, in the centre of which is seen the lymphatic gland only slightly enlarged. The process is often slow, and a good deal of cutaneous redness is present with but little pus.

Treatment consists in keeping the sore clean, dusting its surface with iodoform, and covering it with lint dipped in lotio nigra or boric acid lotion, healing usually occurring in from ten to twenty days; where much balanitis exists, it may be necessary to slit up the prepuce, but circumcision should not be undertaken until the sores have healed. The application of pure carbolic or nitric acid may destroy the organisms and hasten a cure, but they need not be employed unless the routine treatment fails to check the spread of the sore. If the smell of iodoform is objected to, iodol or aristol may be substituted.

Buboes are treated in the early stages by keeping the patient at rest and applying fomentations or Klapp's suction balls, when resolution sometimes occurs. If suppuration ensues, the abscess should be incised vertically, so as to allow free exit to the pus, even when the patient is sitting, the cavity being subsequently dressed by packing it with gauze impregnated with iodoform. Some surgeons make small incisions, and trust to the suction effect of Klapp's apparatus; others recommend that the enlarged glands should be freely removed by dissection, but such is not often required. The tissues surrounding them are so extensively infiltrated that it is sometimes impossible to define their limits, and surrounding tissues of importance may be encroached on. Moreover, complete removal of the lymphatic glands in the groin is sometimes followed by serious evidences of lymphatic obstruction in the limb or external genital organs (Fig. 120). Prolonged rest, free incisions, and scraping of abscess cavities and sinuses, followed by packing with iodoform gauze, usually result in a cure; when repair is slow, a visit to the seaside will often be beneficial.

Syphilis.

It is now fairly certain that the cause of syphilis is a protozoal parasite discovered by Siegel and Schaudinn in 1905, and termed the *Spirochæta pallida* or *Treponema pallidum* (Fig. 31). Spirochætes and spirilla are common in the mouth and in dirty wounds; but this organism can readily be distinguished from unimportant forms by its morphology and staining reactions. It has recently been cultivated by Noguchi on a mixture of agar and ascitic fluid under strict anaërobic conditions. It stains with difficulty, a fact which accounts for its having eluded observation for so long. Morphologically, it is a very delicate spiral filament, having eight to twelve fairly regular whorls; its ends are sharply pointed, and each terminates in an exceedingly delicate flagellum. It varies in length, but on an average is about equal in length to the diameter of a red blood-corpuscle, and each whorl occupies about 1 μ. The common *S. refringens*, which is frequently met with in the mouth, ulcers, etc., is larger, broader, has blunter ends, and a smaller number of less regular whorls. Little is known of the life-history of the syphilitic form.

The proof of its specificity lies mainly in the fact that it can be found in the great majority of all cases of syphilis—the proportion depending on the care taken and the skill of the observer—and that it is found in regions in which accidental contaminations could hardly occur, *e.g.*, in the lungs, liver, spleen, and other viscera of still-born syphilitic fœtuses (Fig. 32). In acquired syphilis it may be demonstrated in the earliest stages of the sore that precedes the typical primary chancre, or in scrapings thereof; in the secondary stage it occurs in the corresponding glands, the skin lesions, or in the fluid of blisters raised near them, in the spleen, and has been demonstrated in the blood, though rarely; in the tertiary stage it has been found in small numbers in gummata and other specific lesions, but in the majority of cases it can only be demonstrated with great difficulty and after prolonged search; especially is this the case in the so-called parasyphilitic affections of the nervous system.

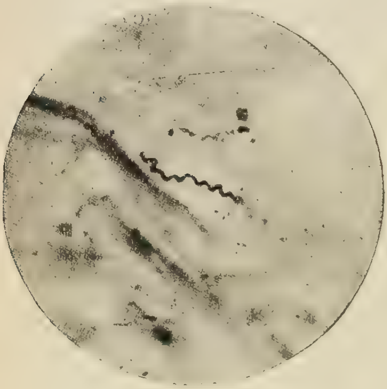

FIG. 31.—SPIROCHÆTA PALLIDA. (× 1,500.)

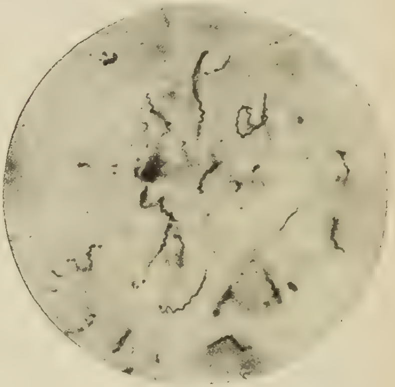

FIG. 32.—SECTION OF LUNG IN DEAD AND MACERATED SYPHILITIC FŒTUS, SHOWING THE TISSUES CROWDED WITH SPIROCHÆTES. (× 1,000.)

(For the preparation and loan of these two specimens we are indebted to Dr. Eardley Holland.)

Syphilis only occurs naturally in man, but it may be inoculated into the higher apes, which develop a disease comparable in most of its features to human syphilis. Frequently repeated experiments on these animals have yielded results of much clinical interest. The disease has been transmitted by material obtained from the human subject in all stages—*e.g.*, by the blood, the semen, discharges from the primary sores, from secondary lesions, and even from gummata. The incubation period is from three to four weeks, and then an indurated nodule appears which undergoes ulceration, and is accompanied by enlarged lymphatic glands. Mild secondary symptoms usually follow, but tertiary manifestations have not been observed. It has been proved that the inunction of calomel ointment locally can prevent infection, even up to twenty hours after inoculation; but removal of the inoculated region has proved useless except when undertaken within eight hours after infection.

The methods employed in the **Laboratory Diagnosis** of syphilis consist in the demonstration of the spirochæte or in the Wassermann reaction. The *Treponema pallidum* can usually be found without difficulty in the serum which oozes from the margin of the supposed chancre after scraping it lightly with a scarifier, or which can be expressed after puncture of an enlarged lymphatic gland. Long before the sore has taken on a typical appearance the spirochætes can be seen and a diagnosis made, and it is important to realize that the induration of the sore is Nature's attempt to shut in the organisms, and therefore it is the more difficult to reach them by drugs. No antiseptic should be applied to the sore before examination, as thereby the spirochætes are driven into the deeper tissues. Three methods of demonstration may be employed: (1) The material may be examined fresh under dark background illumination (ultramicroscope). This is the best method, the organisms being easily seen and their characteristic movements recognised. (2) Appearances somewhat similar can be secured by mixing the secretion with fluid Indian ink, spreading it out into a film, and allowing it to dry on a slide. Here also the organisms appear colourless on a dark ground, but, of course, there is no movement. This is a simple and quick method. (3) There are numerous staining methods, most being modifications of Romanowski's; photographic processes depending on the reduction of silver salts are also used, especially when the organisms have to be sought for in the tissues.

The *Wassermann reaction* depends on the fact that in the late primary, secondary, and tertiary stages of the disease the blood-serum usually contains a substance which, when incubated with an alcoholic extract of heart or liver (diluted with saline solution), removes complement (p. 22) from the mixture. This is demonstrated by adding sensitized red corpuscles, which are dissolved if complement is present, but which remain unaltered if it is absent.

A positive Wassermann reaction is obtained in a few diseases other than syphilis—viz., in yaws, leprosy, and scarlet fever, but in the last it is inconstant and only present for a few days. In syphilis the positive reaction usually appears about the time of induration of the sore. It is present in all late primary and secondary cases. At the onset of the tertiary period a few patients are found in whom it is absent, and these gradually increase in number, until in very old-standing cases the positive results fall from 95 to somewhere about 80 per cent.*

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* These figures refer to patients who have been treated in the old-fashioned way by mercury only.

The **Clinical History** of syphilis varies widely in different cases according to the virulence of the infection and the degree of resistance of the tissues, but as a rule the three stages suggested by Ricord are observable. The *primary* stage includes a varying period of incubation, and the appearance of a sore, usually known as a 'hard chancre.' This is followed in the course of a few weeks by evidences of *general* infection, referred mainly to the skin, mucous membranes, and lymphatic glands, comprising the *secondary* stage. After a variable time, perhaps extending to many years, during which symptoms may be absent, *tertiary* manifestations (gummata, etc.) may show themselves in any and every part of the body.

Mode of Infection.—Acquired syphilis is almost always due to infection of the genital organs arising from impure connection. Occasionally cases are met with in which the disease is acquired innocently by direct or indirect contact with syphilitic lesions (*syphilis insontium*), and then the primary lesion is often located on some other part of the body (*extragenital* chancres). Thus, the lip may be infected as a result of drinking out of the same glass or smoking the same pipe as a syphilitic patient, or even by kissing. Metchnikoff has proved that the spirochæte is a delicate organism, and quickly loses its virulence outside of the body. This probably explains the rarity of infection by indirect contact. An additional protection is the fact that the organisms cannot enter the system through unbroken skin or mucous membrane. The disease is not equally infectious in all its stages; in the primary, the discharge derived from the chancre will alone convey the contagion; in the secondary period the virus is present in the blood, and consequently in all pathological exudations, as also in the semen. Pure secretions —*e.g.*, tears, milk, or urine—are free from infection, although, if mixed with a serous exudate from abraded surfaces, as so frequently occurs in the case of the saliva, they at once become infective. It is uncommon, but by no means impossible, for infection to be conveyed by patients in the tertiary stage.

One attack of syphilis usually confers immunity on the patient from further outbreaks of the disease, even if exposed to infection. This protection is not always permanent, since well-authenticated cases have been observed of second attacks of syphilis.

The stage of **Incubation** lasts for a variable period, extending from two to six weeks; as a rule, evidences of induration of the sore can be detected about the third week. Removal or destruction of the local lesion has not the slightest influence upon the progress of the case, unless it is undertaken immediately after infection, or unless the patient is being treated by salvarsan. Many spirochætes are shut up within the chancre, and as these are inaccessible to the drug, it is advisable to remove them by operation. During the incubation period the local sore may heal completely, if it is purely syphilitic, and nothing further is noticed until the typical induration manifests itself. Not unfrequently, however, pyogenic infection occurs, or a soft chancre is also present; in the latter case the lesion does not heal satisfactorily, and the base of the ulcer becomes indurated after a time.

I. **The Primary Stage** of syphilis is characterized by the development of a sore, associated with enlargement of the neighbouring lymphatic glands. It is usually situated on the base of the prepuce, close to the corona glandis (Fig. 33), or on the frænum; in the female the inner aspects of the labia majora or nymphæ are the most common sites, but it often causes so little inconvenience as to be overlooked.

The primary sore does not invariably present the same appearance, although it is typically characterized by a certain amount of infiltration and induration. The following are the chief forms in which the chancre manifests itself: (*a*) The *desquamating papule* is a slightly elevated spot, which is irritable, of a dusky colour, and free from ulceration. It is usually small, but hard, and its surface covered with epithelial scales. If exposed to friction or to the irritation of retained discharges, ulceration is very likely to take place, and an ordinary Hunterian chancre will then form. Unless this occurs, it may run its course unobserved, and thus a patient becomes syphilitic without being able to trace the time or source of infection. (*b*) The indurated, hard, or *Hunterian chancre* is that most commonly seen; it results from the irritation of a papule, or is developed in association with a soft sore. Should the initial superficial abrasion have healed, a localized growth of almost cartilaginous hardness forms in the cicatrix, closely adherent to and invading the cutis; but if a soft sore has first developed, the surface remains ulcerated more or less deeply, with a well-defined margin, though the base becomes indurated (Fig. 34). In some cases there may be but little elevation of the growth, and the surface is free from ulceration, constituting the variety known as the 'parchment induration' of Ricord, and most frequently seen on the glans penis. Where, however, the prepuce or body of the penis is involved, the induration is more diffuse, owing to the laxity of the connective tissue. When affecting the base of the prepuce, the induration usually spreads transversely, producing a collar-like mass, which on retraction of the part rolls back *en bloc* in a very characteristic manner (Fig. 33). When the orifice of the prepuce is involved, the part becomes generally infiltrated and hard, so that retraction is impossible, and a form of phimosis is thus acquired. Examined microscopically, the new formation consists merely of a mass of round and spindle cells

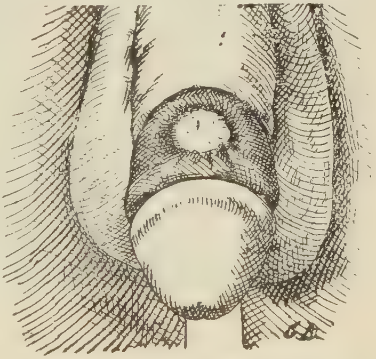

FIG. 33.—HARD CHANCRE, DISPLAYED BY EVERSION OF PREPUCE.

packed closely together, with a certain amount of intercellular fibrous tissue; giant cells are sometimes seen. The blood-supply of the part is scanty, a fact which explains the readiness with which ulceration occurs. It is all-important, however, to remember that *a diagnosis of syphilis can be made by the microscope long before this typical induration appears, and unless this early diagnosis is made, and effective treatment commenced, the possibility of a complete cure is much lessened.*

Several chancres may be seen on the same individual if the infection occurs at one time, and it is possible that a patient may be infected at two different periods if only a short interval elapsed between the inoculations; but the disease is not generally auto-inoculable, and when once a hard chancre has developed on the under surface of the prepuce, the glans does not become infected from contact. Multiple chancres are always of small size, and the induration is less marked than usual.

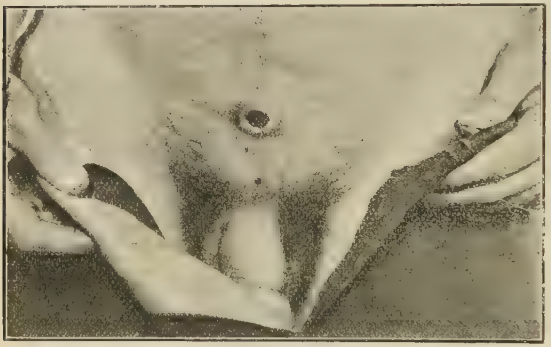

FIG. 34.—HARD CHANCRE OF ABDOMINAL WALL IN SUPRAPUBIC REGION.

A **Urethral Chancre** is usually situated just within the lips of the meatus, constituting a sore with an indurated base. It may be felt as a hard nodule on grasping the urethra between the fingers, and gives rise to a thin serous discharge, often blood-stained. The orifice itself is sometimes the site of a hard chancre, which may encircle it, and be followed by a stricture.

Extragenital Chancres are most commonly observed on the lips, finger, and nipple. They are often characterized by much infiltration, due to pyogenic inflammation, and less distinct and definite induration than in the forms met with on the genital organs; hence the swelling is more prominent and vascular, and if ulceration occurs there is a greater amount of discharge, which forms a thick scab over the surface. Neighbouring lymphatic glands are often much enlarged, and surrounded by infiltrated tissue. This condition has been mistaken for epithelioma, from which, however, it can be distinguished by the induration and sharp limitation of the sore, its rapid development, and the earlier enlargement of the glands. The course of the case is sometimes more severe than when the primary lesion is in the usual situation, a fact possibly explained by the disease remaining unrecognised till secondary symptoms develop.

Digital Chancres are usually seen in nurses, surgeons, and accoucheurs, and start by the side of the nail. An indolent sore appears, which becomes infiltrated and ulcerates, spreading under the matrix and along the semilunar fold. There is a good deal of discharge and pain, and the terminal phalanx becomes swollen and bulbous. The epicondyloid and axillary glands are enlarged as the case progresses, and the condition has more than once been mistaken for malignant disease. Occasionally, however, the sore has been so small and so little obvious as to be overlooked.

Phagedena is a form of spreading ulceration, rarely met with at the present time, except in connection with venereal disease, and seldom apart from syphilis. It always attacks unhealthy and debilitated individuals, and is largely due to the retention of discharges resulting from phimosis. The prepuce and end of the organ become red, swollen, and infiltrated. On dividing or retracting the foreskin, the affected surface is found to be sloughy, and the ulceration, unless checked by treatment, rapidly spreads, and may destroy glans and prepuce, and even attack the body of the penis. **Treatment** consists in division of the foreskin if that structure has not been already destroyed, followed by repeated immersion of the patient in a hot hip-bath. In the intervals the wound should be dusted with iodoform, and dressed with lint dipped in lotio nigra. The later treatment is conducted as for primary syphilis, although the depressed condition of the general health may necessitate the administration of tonics, and even a visit to the seaside. Should treatment by immersion in hot water be for any reason impracticable, the old-fashioned plan must be resorted to—viz., scraping the sore, and freely cauterizing the base with pure carbolic or fuming nitric acid. Possibly, where there is much slough, this latter method may advantageously precede immersion in a bath.

The **Lymphatic Glands** which receive lymph from the region in which the sore is situated become characteristically enlarged. They move freely under the skin and feel hard, like bullets, pellets of cartilage, or almonds (hence the term ‘ amygdaloid ’ which has often been applied to them); they are usually quite painless, and do not suppurate unless the original sore is inoculated with the virus of a soft chancre or with pyococci.

Occasionally the lymphatic vessels extending from the sore to the glands become the seat of a chronic lymphangitis, and may be felt as hard cords beneath the skin. The dorsal lymphatic of the penis is frequently blocked in this way, and gives rise to solid or lymphatic œdema of the prepuce and glans. Should the chancre suppurate, an abscess may also form in the course of the lymphatics.

The **Diagnosis** of a syphilitic from a soft sore is not always easy. Of course, where there is no ulceration, and the typical induration of the base can be felt, no doubt need arise. But when the primary sore suppurates, and an excavated ulcer is present, surrounded by infiltrated and hyperæmic tissues, it is difficult to be certain as to the nature of the case. The inguinal glands are enlarged in both varieties, and the fact that suppuration occurs proves nothing. Even the existence of a ‘ satellite ’ chancre from auto-inoculation only demonstrates the presence of a soft chancre; it does not prove the absence of syphilis. The presence of the typical spirochæte in scrapings from a chancre, or in juice removed by a hypodermic needle from an enlarged inguinal gland after massage, is conclusive evidence. Rarely is it necessary to wait for the development of secondary symptoms before a decided opinion can be given.

The **Duration** of the primary sore varies in different cases, and depends in a great measure on whether treatment is commenced early or late. If the patient comes under observation during the first six weeks, and a mercurial course is at once started, the chancre heals, and the induration usually disappears in from six to eight weeks. The glands in the groin, however, remain enlarged for some time. The longer the case is left untreated, the more slowly does the hardness disappear. If no mercury is given, the induration may last for twelve months or more, and then slowly passes off, although it may run a much shorter course. From an uncomplicated syphilitic sore but little scar results, although a well-marked cicatrix may follow a soft or suppurating chancre.

Re-induration of the cicatrix (**relapsing chancre**) sometimes occurs from too early a cessation of the mercurial course, or from some localized irritation, or from a fresh exposure to infection. It is occasionally due to a tertiary or gummatous development, and will then be free from lymphatic complications.

II. **Secondary Syphilis.**—In the secondary stage, the virus is diffused generally throughout the body by means of the blood, which is itself infective. A certain amount of constitutional disturbance may exist, the patient feeling 'seedy' and out of sorts, whilst in some cases distinct pyrexia, wasting, and headache have been noted. Well-marked anæmia is often present, and on examination the red corpuscles are found to be deficient in number, and defective in the amount of hæmoglobin contained within them. A moderate leucocytosis is present, chiefly involving the lymphocytes and plasma cells. The chief secondary manifestations consist in a general enlargement of the lymphatic glands, together with the appearance of various forms of rash on the skin and mucous membranes, loss of hair, and other less common phenomena, involving the eyes, brain, etc.; these usually show themselves in from six to nine weeks from the time of inoculation, although they may be delayed to a much later date. Their intensity varies considerably, the phenomena being sometimes scarcely evident, and at others very marked. They are also influenced greatly by the period at which treatment commences; the earlier it begins, the less obvious are the secondary phenomena.

The **Cutaneous Eruptions** of secondary syphilis are chiefly characterized by the fact that, although any form of rash may be simulated, no specially distinctive variety is originated. Moreover, in the same individual the eruption is not always of the same character throughout, several distinct types developing in different parts of the body (*polymorphism*). The rashes are usually more or less symmetrical, the colour in the early stages being a dusky red, resembling that of raw ham; occasionally, however, they may be a bright rosy red. Syphilitic rashes disappear after a time, but often leave a coppery-brown discoloration of the skin for a while; moreover, they do not completely fade on pressure, but leave a similar brown stain, and give rise to but little irritation or itching; they always tend to progress from the simpler types, due to hyperæmia, to the more serious, in which infiltration and overgrowth are evident.

The simplest form consists of a mere hyperæmia, sometimes appearing as a dusky mottling of the skin (*roseolous* syphilide), which quickly fades or may persist whilst other types are developing. Sometimes distinct papillæ become infiltrated and hyperæmic (*papular* syphilide); at others, vesicles or pustules appear (*vesicular* or *pustular* syphilides); the latter change is uncommon, and only appears in bad cases or in debilitated patients. Another form of eruption is the *squamous* syphilide, characterized by patches of hyperæmia and infiltration, combined with superficial desquamation. It is usually bilateral, and, unlike simple psoriasis, affects the flexor rather than the extensor surfaces. In the later stages, distinct nodules or tubercles are produced in the skin, which may even run on to ulceration (*tubercular* syphilide).

As to the *situation* of the rash, the roseola is usually limited to the trunk, whilst the other forms are often scattered widely over the trunk and extremities, involving, however, the flexor more than the extensor surfaces of the limbs. A somewhat characteristic phenomenon is the appearance of a papular rash on the forehead, sometimes known as the *corona Veneris*.

The **Mucous Membranes** may be affected in much the same way as the skin. The fauces become red and congested, the hyperæmic area being abruptly limited, and semicircular in outline; symmetrical ulceration usually follows, starting near the anterior pillars of the fauces, and spreading to the tonsils and along the soft palate to the uvula. These ulcers are shallow, have sharply-cut edges, and often present a characteristic grayish appearance, constituting what is known as a 'snail-track' ulcer. The secondary sore throat rarely results in extensive loss of substance, and hence pharyngeal stenosis is not produced. Smoking undoubtedly aggravates these conditions. Concurrently with these manifestations in the fauces bare patches from loss of epithelium may be seen on the dorsum of the tongue, or several small superficial, but very painful, ulcers may develop on the inside of the cheeks or lips, or along the borders of the tongue, from the irritation of the teeth.

Mucous tubercles and condylomata are somewhat similar affections, though more pronounced, arising in the secondary stage in connection with mucous membranes and those parts of the skin which are soft and moist. *Mucous Tubercles* consist of slightly-raised patches of enlarged and infiltrated papillæ, white in appearance from the superficial epithelium becoming sodden, and often progressing to actual ulceration. Examined microscopically, the papillæ are found to be definitely enlarged, and the epithelium heaped up over them. They are most commonly observed at the corners of the mouth, on the inner aspect of the cheeks, the side of the tongue, or the margin of the anus; in the last-named situation they are usually symmetrical, one side being infected from the other. They are also not at all uncommon between the toes, and the ulcers caused thereby become exceedingly offensive. *Condylomata* are similarly the result of overgrowth of the papillæ, differing from mucous tubercles merely in the extent to which this has been carried. They consist of definite wart-like masses, which may attain a great size, constituting a cauliflower-like growth. They are most commonly seen about the anus or vulva, in the former situation being often mistaken by the patient for piles; they give rise to an abundant, highly infective discharge. A similar condition is sometimes met with on the dorsum of the tongue, and is then known as 'Hutchinson's wart.'

The **Lymphatic Glands** are usually enlarged throughout the body during this period of the disease, being felt as round, hard swellings beneath the skin. The extent of the glandular complication is possibly a measure of the degree of virulence of the affection. Chronic enlargement of the nuchal and epicondyloid glands, in the absence of any obvious local cause, is always suggestive of the existence of syphilis.

Syphilitic Alopecia.—The hair becomes dull and lustreless, and either comes out in patches from the scalp, eyebrows, beard, etc., or there is a general 'thinning.' The follicles, however, are not destroyed, and after a time the hair will grow again as before.

Later secondary manifestations consist of flying pains in the bones (osteocopic), iritis, and various nervous lesions, whilst periosteal nodes may form on the tibiæ and other bones, or a symmetrical chronic effusion develop within the synovial membrane of joints.

Syphilitic Iritis is characterized by pain in the eye, generally referred to the supra-orbital nerve, together with some interference with vision, and possibly a little lachrymation and photophobia. On examination a bright-red circular zone immediately surrounds the cornea, resulting from hyperæmia of the ciliary vessels. The iris is lustreless, and its definition somewhat blurred. Its colour is changed, a blue iris becoming greenish-yellow from the presence of lymph. The pupil is diminished in size, and perhaps irregular; its movements are always considerably hampered, and sometimes entirely prevented, by the formation of adhesions either to the back of the cornea (anterior synechiæ) or to the lens capsule (posterior synechiæ). Occasionally small yellowish nodules are seen on its surface, consisting of plastic lymph.

The **Duration** and character of the secondary stage vary considerably. The sooner effective treatment is commenced, the less severe the secondary phenomena, whilst cases in which treatment has been delayed are likely to be more troublesome. Hence the disease is often of an aggravated type when following extragenital chancres, as also in women, by whom the primary lesion often passes unnoticed. When treatment is commenced within four or five weeks of infection, the secondary stage may be slight, and all traces of its existence may pass off in two months or less; if treatment is delayed until the cutaneous eruption has appeared, this stage is likely to last longer. The condition of the patient's health is an important factor, as also the previous habits, particularly as to temperance, since syphilis always follows a more aggravated course in the weakly and the dissipated. Patients suffering from the debility caused by malaria or other tropical affections are particularly bad subjects, and the disease may then run a virulent course. Even under the best circumstances, the patient is liable to *relapses* during the first twelve months, which are usually due to intermissions in the treatment. The rash which appears under these circumstances is often of a more characteristic type, the papules being grouped into rounded or confluent figures.

III. The **Intermediate or Late Secondary Stage** constitutes a link between the symptoms already described and the tertiary phenomena; no distinct limits to this period can be defined, nor need it appear at all if the patient's general health is good, and the treatment has been carried out regularly. Some of the secondary manifestations, especially those of the bones and joints, may persist through this period, whilst even if they have disappeared the patient is liable to suffer from 'reminders' in the shape of various cutaneous affections, and perhaps epididymitis. The *bloodvessels* are not unfrequently affected in this and later stages of the disease, the endothelium of the tunica intima undergoing proliferation (Figs. 97 and 98); the lumen is thereby diminished, and the nutrition of the part supplied may be lowered. Arterio-sclerosis of the larger trunks may be induced by an affection of this type involving the vasa vasorum, and various forms of nerve trouble may be lighted up if the cerebral vessels are involved. Paralysis of a single limb (monoplegia) may result, or of one side of the body (hemiplegia); but the affection may be limited to a single cranial nerve, or merely result in a severe headache. Unfortunately, treatment may be incapable of remedying the mischief caused in this manner. Deep ocular lesions (*e.g.*, choroido-retinitis) are also not unusual. The principal cutaneous affection is the so-called **syphilitic psoriasis,** most frequently seen on the palms and soles. A squamous syphilide is often observed in the secondary stage, but is then symmetrical and readily influenced by mercury. In this intermediate period the lesion may be bilateral or limited to one side, according to whether it appears early or late. In the former there is a considerable tendency to proliferation of the epithelium, together with deep cracks and fissures; in the latter there is less epithelial overgrowth, but the edges are often distinctly serpiginous in outline, and there is an infiltrated border.

Rupia and **Ecthyma** are both met with in this stage of the disease, but chiefly in patients whose nutrition is defective. They are characterized by an infiltration of the skin (in reality gummatous), which progresses to ulceration. In rupia the discharge forms a distinct scab on the surface, which increases in thickness by the deposit of successive layers one under the other, each being somewhat larger than the one which precedes it; hence a scab shaped like a limpet-shell is produced, resting on an inflamed and hyperæmic base (Fig. 35); any part of the body may be affected in this way. In ecthyma no scab forms over the ulcerated surface, or, if formed, it readily comes away, leaving exposed a hollow punched-out sore, surrounded by an area of vivid congestion. Under appropriate treatment these conditions disappear, but leave depressed, whitish cicatrices, often surrounded by pigmentation.

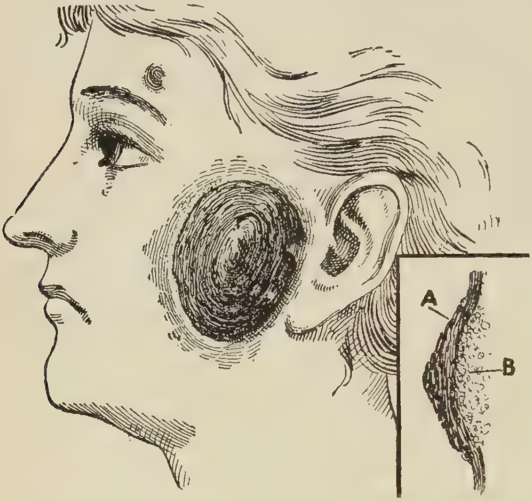

Fig. 35.—Rupia of Face. (From Wax Model in Museum of Royal College of Surgeons.)

A diagrammatic section of the rupial patch is shown at the side. *A*, Scab formed of successive layers of dried discharge resting on *B*, ulcerated granulomatous surface of gumma.

A somewhat unusual intermediate manifestation is a subacute symmetrical epididymitis, in which the cord also becomes thickened, enlarged, and tender.

IV. **Tertiary Syphilis.** — The phenomena occurring in this stage may appear within six months of infection, or not for twenty or thirty years. They are mainly characterized by infiltration and overgrowth of the connective tissues of the body. Such may occur in one or many places, and may be diffuse or localized. When diffuse, the organ or part affected becomes enlarged and hard, and unless the condition is treated promptly, remains permanently sclerosed from the development of fibro-cicatricial tissue. If, however, the process is localized, a **Gumma** is formed.

Any tissue in the body may be the seat of a gummatous deposit, which apparently arises without any definite cause, although occasionally its onset may be determined by an injury. The involved area becomes infiltrated with large oval endothelial cells and small round cells (lymphocytes); plasma-cells are usually present in considerable numbers. The constituents of this mass are quite similar to those which are found in a tubercle, but without the grouping into small nodules and the more or less orderly arrangement in zones; giant cells are usually absent, though their presence is by no means rare, and they may closely simulate the tuberculous type. Very few vessels penetrate into the mass thus formed, which otherwise resembles granulation tissue; it gradually increases in size, infiltrating and replacing the normal tissues of the part. The fate of the fully-formed gumma varies according to circumstances. If the infection is a mild one, and especially if appropriate treatment is adopted, the bulk of the cells become absorbed, and the remainder are organized into fibrous tissue; even a large gumma may almost entirely disappear, leaving but a small fibrous scar.

In the absence of proper treatment most gummata undergo a necrotic change, which commences at the centre of the nodule and spreads towards the periphery. This may be a comparatively slow process, accompanied by fatty degeneration and caseation somewhat similar to that seen in tubercle; or it may be more rapid, the tissues undergoing a kind of mucoid degeneration, forming a gummy mass from which the lesion acquires its name. Sections through such a gumma will show a large white structureless centre of necrotic or caseous material, surrounded by a shell of cellular tissue, which gradually merges into the normal structure of the part. Two factors are concerned in the production of this necrosis: the toxins produced by the causative organisms, and the deficient blood-supply of the central portions of the cellular mass. The vessels of the gumma are deficient from the first, and after a time the amount of blood which reaches them is diminished as the result of syphilitic endarteritis. Moreover, some gummata do not commence to undergo central necrosis until a certain amount of transformation into cicatricial tissue has taken place, in which case a still further interference with the blood-supply may be caused by the compression of the vessels traversing the newly-formed fibrous tissue.

Under appropriate treatment the whole of the gummatous mass may be absorbed, even when caseation or necrosis has taken place; but not unfrequently the gummy, semi-purulent fluid which is formed at the centre of the mass finds its way to the surface and is discharged. Where the necrotic mass is large, a portion of it may remain adherent to the surrounding tissues after ulceration has taken place, looking somewhat like a piece of wet wash-leather. Occasionally the central slough may become encysted by the formation of a fibrous capsule, and calcification may occur; this is most frequently found in the brain, testis, and liver.

Clinically, the appearances vary according to whether the gumma is cutaneous or subcutaneous.

Cutaneous gummata are very frequently observed in tertiary syphilis, especially in the earlier stages. They occur as rounded dusky red nodules of firm consistency, but slightly painful, and if they break down give rise to typical circular ulcers (Fig. 36). Many such growths are often grouped together in one region, and when ulceration has occurred they produce by their confluence sores with a rounded or serpiginous outline. Considerable destruction of tissue follows, but they are readily cured, giving rise to depressed white cicatrices, surrounded by pigmentation. Any part of the body may be involved, but a very common site is about or just below the knee on the outer, rather than the inner, aspect of the leg.

Occasionally a diffuse infiltration of the skin is met with in this stage, appearing as a red hyperæmic area with a rounded or serpiginous border, and not at all unlike lupus in appearance (Fig. 37). It spreads rapidly at the margin, which is distinctly thickened, and may contain scattered nodules undergoing ulceration. Whether ulceration occurs or not, a cicatrix is produced. It is readily amenable to treatment, and runs a much more rapid course than lupus; the apple-jelly-like granulations so typical of the latter disease are of course not present.

A *subcutaneous gumma* develops as a firm nodule or an indefinite thickening, which gradually increases in size by the infiltration of surrounding tissues, and sooner or later approaches the surface; the centre of the tumour in time becomes elastic and fluctuant; a certain amount of pain and tenderness is noticed, and when the skin is affected it becomes dusky, and even œdematous. If ulceration follows, the contents of the gumma escape, and the sore produced is circular and deep, the edges being sharply cut and perhaps undermined; the base of the ulcer consists of granulation tissue, although it is sometimes covered by the characteristic slough.

The tertiary syphilitic affections of special organs will be described under the appropriate headings; but the general relation of syphilis to the nervous system (the so-called *parasyphilis*) has been purposely omitted, since it belongs rather to the physician than to the surgeon.

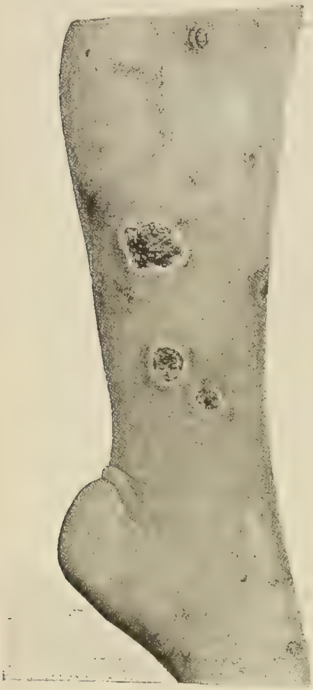

FIG. 36.—CUTANEOUS GUMMATA OF LEG AND PIGMENTED SCARS.

The **Prognosis** of syphilis has been transformed of recent years by two factors. (*a*) The possibility of demonstrating the presence of the spirochæte in the primary sore, before any typical induration has occurred, has placed in our hands a means of early diagnosis which is certain, and of which every advantage should be taken by the practitioner. (*b*) The discovery of salvarsan enables us to destroy the spirochætes, which are accessible to its influence. Organisms which are shut up in the fibrous-tissue meshes of a chancre, or in the deeper recesses of the cerebro-spinal axis, are to a large extent inaccessible. Hence the prognosis of syphilis may be stated to be entirely a matter of early diagnosis.

It is, of course, at present a little too soon to dogmatize on the ultimate results of modern treatment, but the statistics published by both naval and military surgeons, who have a unique opportunity of studying the disease, are most encouraging, and hold out hopes that this scourge of mankind has at length been brought under control. Thus Gibbard and Harrison* state that, of 378 patients treated exclusively by regular courses of mercury, 83 per cent. relapsed clinically at least once during the first year; whereas, of 152 patients treated by salvarsan and mercury, only 3·9 per cent. relapsed clinically within a year of the suspension of treatment. Similarly, Bodley Scott† expresses his conviction that 99 per cent. of cases could be cured effectively if a diagnosis were reached and treatment commenced within a few days of infection; whereas if treatment is delayed until the Wassermann reaction becomes positive or the sore indurated, only 60 per cent. of cures will result, and doubts as to the permanence of the cure may well exist for the next fifteen years. Prolonged treatment by mercury alone gives moderately good results if the disease is recognised early.

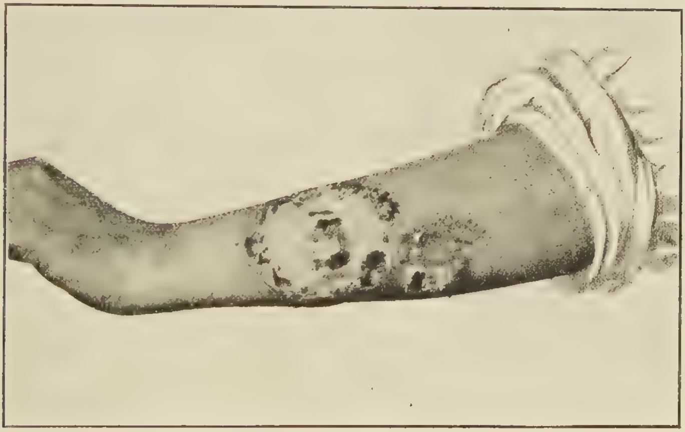

FIG. 37.—DIFFUSE GUMMATOUS SORE OF FOREARM.

Some strains of the spirochæte appear to be more virulent than others, especially those acquired in the tropics, and some systems are apparently more receptive than others. Idiosyncrasies preventing the administration of salvarsan, mercury, or iodide of potassium, are particularly unfortunate. The state of health of the patient at the time of inoculation may influence the evolution of the case, whilst the co-existence of tuberculous disease may render the outlook very unfavourable, especially when the syphilis is inherited. The character of the secondary rash and the extent of the general glandular enlargement may give some indication of the gravity of the case; a pustular eruption is almost always of grave import.

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* Colonel Gibbard and Major Harrison, *Brit. Med. Journ.*, November 22, 1913, p. 1341.

† Surgeon Bodley Scott, R.N., *Brit. Med. Journ.*, November 22, 1913, p. 1344.

Death is rarely produced by any of the secondary manifestations, except in the virulent forms developed in the tropics; but it is not uncommon in the tertiary stage, when important viscera, such as the brain, spinal cord, liver, etc., are involved. Affections of the nervous system, such as tabes and general paralysis, are likely to be developed in patients, such as doctors and lawyers, whose life-work entails considerable nervous and mental strain. Certain cases are to be looked on as practically incurable (*malignant syphilis*), owing probably to the virulence of the infection, and to the late period at which treatment was commenced. This condition is most often seen in women, and in them the rash quickly becomes of a rupial or gummatous type, the secondary manifestations running over into those of the tertiary period at an early date.

It is probable that syphilis can be prevented by washing the part exposed to infection with a solution of corrosive sublimate, and rubbing in a calomel ointment (30 per cent.), if such treatment is undertaken within an hour or two of infection. This has been proved experimentally in apes, and certainly in one carefully observed case in the human subject.

The **Treatment** of syphilis has been transformed of recent years by the recognition of its protozoal origin, and its kinship to sleeping sickness and other similar diseases. Attempts to treat it with organic preparations of arsenic were not very successful at first; substances of the arylarsonate type, such as atoxyl, soamin, arsacetin, etc., were tried, but, although a few good results were obtained, the majority were disappointing, and some disastrous, inasmuch as the prolonged use of such drugs was found to be followed by toxic phenomena, amongst which optic nerve atrophy was one of the most serious. Experiments in this direction were still maintained by Ehrlich and Hata, and finally they introduced a substance now known as *salvarsan*, or '606' (dioxy-diamido-arseno-benzol), which seems to hold out a brilliant future in the treatment of this dread disease. It is a bright yellow powder, slowly soluble in water, and strongly acid in reaction. It may be administered by intravenous or intramuscular injection, preferably the former. The dose for an adult varies from 0·3 to 0·6 gramme, which is dissolved in sterile normal saline solution, made with distilled water. It is then converted into a sodium salt of the base by adding a sufficient quantity of 15 per cent. solution of sodium hydrate to redissolve the precipitate formed when it is first added. This solution is then made up to 250 or 300 c.c. with saline solution, and introduced into one of the veins of the arm at the body temperature. The patient must be carefully prepared as for an operation, a purgative being given overnight, and no food being permitted for three or four hours before or after the administration. He must stay in bed for twenty-four hours, or longer if he manifests any evidence of pyreixa, muscular pains, headache, or other type of reaction, and should take things quietly on the day after the dose.

The effect of salvarsan is, apparently, to destroy all the spirochætes that are accessible to its influence—*i.e.*, in the circulating blood or in the looser tissues; where, however, the infection is of longer duration, and a certain number of spirochætes have become locked up in sclerosed tissues, such as the indurated chancre, or disseminated through a fluid medium, such as the cerebro-spinal fluid, it is impossible for the salvarsan to act on these organisms, and consequently a complete sterilization of the system cannot occur. Under the influence of treatment these cellular infiltrations are absorbed in a few weeks, and a certain number of spirochætes buried therein are again set free, and to rid the system from these a further dose or two of salvarsan will be needed. It must be clearly remembered that salvarsan has not pushed mercury aside in the treatment of syphilis; it has added an element of safety and security, and thereby has diminished the amount of mercury required and shortened the length of treatment.

The course of treatment recommended by army surgeons for cases seen in the earliest stages consists in—(1) An intravenous injection of 0·6 gramme salvarsan; (2) five weekly injections of mercurial cream; (3) a second intravenous injection of 0·6 gramme salvarsan; (4) five more weekly mercurial injections; and (5) a final intravenous injection of 0·6 gramme salvarsan. All cases are kept carefully under observation for at least a year, and this should include the testing of the blood for the Wassermann reaction, at first every month, and subsequently every three months. The slightest sign of relapse, either clinically or by the Wassermann test, indicates the prescription of a second course of treatment similar to the above. If the patient was brought under treatment in the early primary stage, and his blood has shown no sign of relapse during twelve months subsequent to the cessation of treatment, it is unlikely that he will have any later manifestations. If he first came under observation at a later date, and the blood is already positive to Wassermann's test, or secondary symptoms are already present, it is probably wise to make the mercurial course longer, and in severe cases to give mercury for twelve months. Relapses are more common, and the patient must be watched for two years. In tertiary syphilis salvarsan is useful in helping in the cure of active manifestations of the ulcerative type, but mercury and iodide of potassium still maintain their position, and must be chiefly relied on. Over the deep lesions, especially of the parasyphilitic type, salvarsan has but little influence.

Various modifications of administration are utilized by different surgeons, but they are comparatively unimportant. Neo-salvarsan (0·75 gramme for a dose) is sometimes substituted, and other methods of giving mercury are employed—*e.g.*, by inunction. The intervals between the doses of salvarsan are also different, but the essential universally recognised is the combination of salvarsan and mercury. Occasional bad results, such as localized paralysis or deafness, have been reported after a dose of salvarsan, and even death; but such a mishap is exceedingly rare. The reaction is sometimes unduly severe, possibly due to the rapid destruction of large numbers of spirochætes in the blood and the setting free of a large amount of endotoxin, but the percentage of such bad results is surprisingly low.

The value of this treatment cannot be over-estimated, not only from the personal, but also from the public, point of view. The former has been already alluded to, and the future can alone disclose the ultimate percentage of freedom from relapse. From the public standpoint, the chief advantage lies in quickly rendering the patient non-infectious, and thereby diminishing enormously the chances of spreading the disease to others. The chief limitation to its utility is the expense and the amount of special work required in order effectively to carry out the treatment. It is possible that the Government will have to step in and render such assistance available to all members of the community.

Failing the employment of salvarsan, the practitioner can alone depend on the *administration of mercury*, and this must be thorough and prolonged, and even then good results cannot be ensured. Many different methods have been suggested in order that the patient may derive the greatest amount of benefit from the drug with the minimum of inconvenience. (*a*) It is often given *by the mouth*, and preferably in the form of pills, composed of gray powder (grs. i.—iii., t.d.s.), or of the green iodide (gr. ½—i., t.d.s.). Gray powder is perhaps the best means of administering the drug; the patient should commence with 2 grains, three times a day, or in some cases 1½ grains four times a day, combined with a little extract of opium or pulv. ipecac. co. if it causes diarrhœa; but this addition is not always needed. (*b*) *Inunction* of the mercurial ointment is also frequently adopted, and with great success, inasmuch as it is less likely to cause digestive derangements. If the ordinary officinal ointment is employed, a portion as large as a hazel-nut is rubbed into the groin or axilla nightly, the part being washed the following morning, and not used again for this purpose for three or four days; if the ointment is made up with lanoline, a somewhat smaller amount is required. This is one of the best ways of bringing a patient rapidly under the influence of the drug. At Aix-la-Chapelle and Harrogate this treatment is a speciality, and is combined with the daily use of sulphur water and baths. The mercurial ointment is rubbed in daily by glass rubbers or the hand, and the course lasts six weeks, being repeated within the year. (*c*) *Mercurial vapour baths* may be advantageously employed where the cutaneous eruption is very extensive. The patient sits naked on a cane-seated chair, and covered with a blanket or specially-constructed cloak reaching from the neck to the ground, and not touching the body; 20 or 30 grains of calomel are placed on a metal plate surrounded by a trough containing about an ounce of water. The water is boiled, and the calomel sublimed, by means of a spirit-lamp placed under the chair. In about twenty minutes all the calomel will be volatilized, and deposited in part upon the skin of the patient, who perspires freely during the process. He then gets into bed between warm blankets, without wiping the skin. This treatment may be combined with medication by the mouth. (*d*) The *intramuscular* injection of mercurial preparations has much to recommend it, and although alarmists have emphasized the dangers of suppuration, salivation, and emboli associated with it, yet increasing experience has proved it to be safe and efficacious in careful hands, and with due regard to asepsis. The satisfactory results following its extensive adoption by military surgeons are strong arguments in its favour. Insoluble preparations of mercury are mainly relied on, and especially in the form of metallic mercury suspended in a cream.[*] The dose is injected deeply into the gluteus maximus, and the absorption, if slow, is regular, so that it is little likely to cause toxic symptoms.

During the course of mercury, the patient's general health and habits must be carefully regulated; alcohol is forbidden, exercise limited, and strict instructions are given as to keeping the teeth and gums clean. An astringent mouth-wash containing alum and chlorate of potash should be ordered, and it may be necessary to remove or stop diseased teeth, but the dentist must, of course, be informed of the nature of the case. To minimize the risk of throat and mouth trouble, it is wise to stop all smoking for at least six months. The dose of mercury required varies in different individuals, being increased in robust people, and diminished in those who are weak or unhealthy. It should always be pushed until mild physiological effects are produced in the shape of slight tenderness of the gums, but salivation of the patient is undesirable. Full doses are usually required for four or five months, followed by a milder course, which should extend till the end of the first year. It is advisable, however, to insist on a three months' course of mercury twice a year for two and a half or three years.

Symptoms of *mercurialism* are induced in some people by very small quantities of the drug, and hence treatment should always commence with small doses. The gums become soft and spongy, and bleed readily on pressure; salivation follows, or even acute glossitis, whilst the breath becomes offensive. The teeth are loosened and may be shed, and the alveoli may undergo necrosis. Digestive derangements, such as colic and diarrhœa, are also observed. Treatment consists in suspending the drug for a time, and giving a sharp saline purge, whilst the spongy state of the gums is remedied by the use of an alum or chlorate of potash mouth-wash.

Iodide of potassium is essential in the treatment of the tertiary and intermediate stages. It appears probable that its chief action is the removal of gummatous tissue, and that it has little influence upon the causative disease; in order to prevent recurrence, salvarsan or mercury is still required. The dose of iodide should not exceed 5 grains to start with, and is gradually increased, until in some cases 1 drachm four times a day has been reached. Plenty of water should always be taken immediately afterwards to assist in its dilution and facilitate its absorption. A feeling of depression and sinking at the epigastrium is sometimes produced, but may be alleviated by the addition to the mixture of sal volatile (♏xv.) or carbonate of ammonia, as suggested by the late Sir James Paget. Symptoms of coryza often follow, and an acneiform eruption over the shoulders and face, which may disappear on increasing the dose. Occasionally a vesicular, or even bullous, rash is caused by this drug. When large doses are given, bicarbonate of soda or potash must be combined with it, in order to prevent its decomposition by the gastric juice. If mercury is required, it is better to give it in the form of gray powder than to add liquor hyd. perchlor. to the iodide in a mixture, as the latter usually disturbs the digestion. Other drugs, such as sarsaparilla, arsenic, and iron, are often combined with iodide of potassium in the later stages of the disease, and may be useful.

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[*] A useful preparation is as follows:

℞ Hydrargyri .. .. ʒss.
Adipis lanæ anhyd. .. .. ℥ii.
Paraffini liq. (carbolized 2 per cent.) ad ℥v. (by volume).
Finished product = gr. i. in min. x.
Min. x. as a maximum dose once a week.
LAMBKIN (*Brit Med. Journ.*, November 11, 1905).

The **Local Treatment** of syphilitic sores consists mainly in the application of various preparations of mercury. The *primary chancre* should be treated by excision, cauterization, or the use of calomel ointment (30 per cent.), with the object of removing or destroying the spirochætes which may be locked up in the fibrous interspaces and are inaccessible to salvarsan. *Mucous tubercles* in the neighbourhood of the anus or vulva, or between the toes, are best dealt with by keeping them scrupulously dry and clean and dusting them over with powdered calomel and starch, or by the application of calomel ointment, a piece of lint being inserted between opposing surfaces to keep them from rubbing one against the other. Secondary ulceration of the *throat* does not usually require local treatment, as it soon disappears under the influence of mercury. A mercurial gargle may, however, be employed, or in bad cases the affected parts should be painted with glyc. hyd. perchlor. (1 in 2,000). *Superficial gummatous ulcers* are treated by removing the scabs, and applying some form of mercurial ointment. A determined attempt should be made to keep deep gummatous ulcers in an aseptic condition, since the advent of sepsis to such sores, especially if they are connected with bones, makes a marked difference in their progress. In neglected cases the wound may become exceedingly foul, and in chronic cases a hectic temperature and amyloid degeneration of the viscera have been observed. When gummata come to the surface and point, they should be opened with the same precautions as are adopted in the case of an abscess, and either dressed antiseptically or their cavity packed with sterilized lint or gauze soaked in sterilized lotio nigra.

Inherited Syphilis.

The offspring of syphilitic parents often fails to arrive at maturity, the mother miscarrying at the end of six or seven months. The child may be well formed, and may even live independently for a short while, but not unfrequently it is dead, and in many cases macerated; under these circumstances the tissues of the body are often swarming with spirochætes (Fig. 32). The miscarriage may be repeated for several pregnancies, and then a living child is produced. In other instances, however, a living child is born at full term at the end of the first pregnancy in spite of the syphilitic infection of the parents. This child may show evidences of the disease at birth, but more frequently appears to be healthy, specific manifestations not showing themselves for some weeks.

Much discussion has arisen in the attempt to explain these phenomena, and also as to the relative frequency of infection by the father or mother. Theoretically, infection may occur at one of three periods: (*a*) At impregnation the disease may be conveyed by one or both parents, either the ovum or spermatozoon, or both, carrying the spirochætes. The organism has been demonstrated in the semen of human beings as well as of apes. Infection *ab initio* is likely to be followed by a general development in the tissues, and possibly the cases where the mother aborts early and produces a dead fœtus infiltrated with spirochætes belong to this type. (*b*) During the pregnancy infection of the fœtus may occur through a specific infection of the endometrium, especially involving that portion of the decidua which enters into the formation of the placenta. As a general rule the fœtal and maternal circulations do not commingle, but when the placenta is diseased it is easy to understand that the spirochætes might pass from mother to fœtus. (*c*) It is possible that infection may be delayed until parturition, the organisms then finding their way from the separating placenta through the umbilical vein. Such an occurrence may explain the delay of symptoms in the infant for some weeks after birth, although possibly this is due to a removal of toxins into the maternal circulation during pregnancy so that, although the fœtus is infected, symptoms are kept in abeyance. In this connection it is interesting to note that, although infective lesions may be present in the maternal passages, primary chancres are not seen in infants; they are presumably protected either by a previous infection or by the presence of the vernix caseosa.

In some cases the mother has shown no obvious evidence of syphilis, and yet is able to suckle her child without harm, even though there are ulcerating lesions on the child's gums and lips, whereas a healthy wet-nurse develops a chancre of the nipple. This is known as *Colles's Law*, and was first stated by him in 1837. The immunity of the mother under these circumstances was formerly attributed to the production of antibodies in the fœtus and transmission, to the maternal blood; but the researches of Neisser on the higher apes have shown that the serum of a syphilitic subject contains neither protective nor curative substances, and it is therefore probable that the maternal immunity is due to a mild and unrecognised infection with the disease itself.

Profeta's Law is the reverse of Colles's, and asserts that the child of a syphilitic mother or father is immune to syphilis, although it has never presented evidences of infection with the disease. In the light of modern research it seems extremely probable that this is not true.

The length of time during which a syphilitic patient retains the power of transmitting the disease to the fœtus is an exceedingly difficult point to determine, and one which is constantly coming before the practitioner, who is asked to decide at what period marriage is safe. The rule of practice generally followed is that no one suffering from syphilis should be allowed to marry until the Wassermann reaction has remained negative and he or she has been free from all symptoms for two years, and even then it is advisable that a mild course of mercury should be given for about three months shortly before marriage.

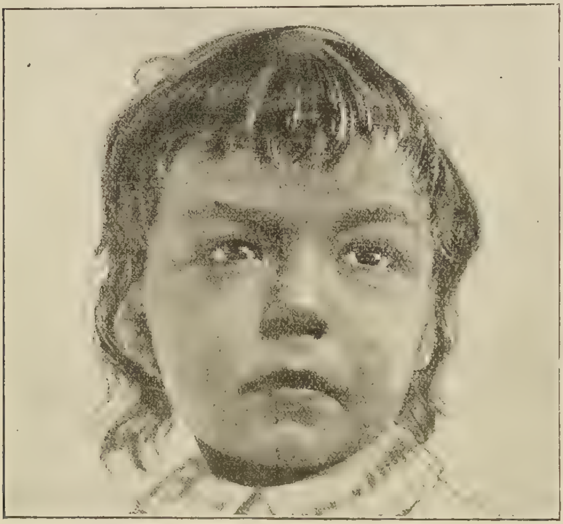
FIG. 38.—CHILD WITH INHERITED SYPHILIS, SHOWING RADIATING SCARS ROUND THE MOUTH. (FROM A PHOTOGRAPH KINDLY LENT BY DR. G. F. STILL.)

The question of transmission to the third generation is one of much interest, concerning which a good deal of conflicting evidence has been forthcoming. The dependence of this disease upon a recognised organism, which it has been possible to demonstrate in late tertiary stages, is presumptive evidence in favour of its transmissibility; but, naturally, one of the chief difficulties is the demonstration of the sexual purity of the second generation. Further evidence of an assured character on this point is much needed.

At birth the child often appears healthy and well nourished, but is sometimes small and imperfectly developed. The first definite symptoms of the disease manifest themselves at a variable period, extending from three weeks to three months, after birth; the child becomes thin and emaciated; the skin, which hangs in wrinkles over the body, changes to a dull earthy colour, whilst the features looked pinched and wizened, like those of an old man. Marked anæmia is always present, and may persist for a considerable time. Speaking generally, the symptoms of inherited syphilis are similar to those of the acquired disease, except that the primary lesion is absent. Thus, during the first year of life the child develops various cutaneous eruptions, mucous tubercles, and superficial ulceration of the mucous membranes. A dusky red roseola, especially about the nates (napkin area), may first be noticed, but does not last long. This is usually followed by the appearance of mucous tubercles at the angles of the mouth, in the nose, and around the anus, as also in the moist folds of the groin, and between the scrotum and thigh. The sores on the lips are sometimes very marked, giving rise to ulcerated surfaces, which, by their subsequent cicatrization, leave radiating scars (or rhagades), especially about the angles of the mouth (Fig. 38). Other cutaneous affections, such as squamous syphilides of the soles of the feet, together with papular syphilides of the body, and a bullous eruption becoming pustular (pemphigus), are also observed, the last-mentioned, however, only occurring in debilitated infants. A catarrhal rhinitis is a very early and constant manifestation, giving rise to obstructed nasal respiration, or *snuffles*. This affection is often protracted, going on to ulceration and destruction of the nasal bones and cartilages; their subsequent development is thus prevented or impaired, and hence the bridge of the nose remains depressed and sunken, even when adult life is reached (Fig. 39). Enlargement of the spleen and liver is also common.

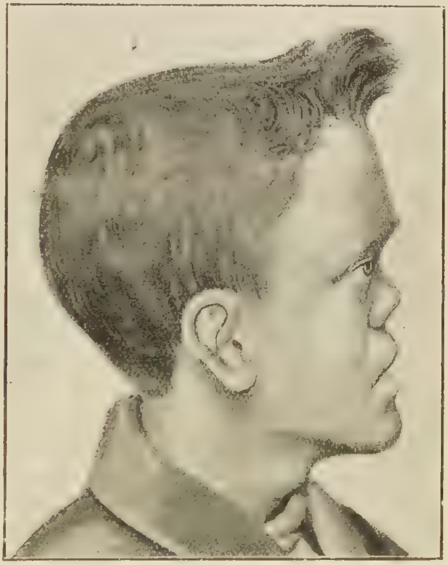

FIG. 39.—HEAD AND FACE OF A PATIENT WITH INHERITED SYPHILIS, SHOWING DEPRESSED BRIDGE OF NOSE AND FRONTAL BOSSES. (FROM A PHOTOGRAPH.)

Many infants during the first year of life die from malnutrition or marasmus; but if properly treated a considerable proportion regain their health within six or eight months, all the manifestations described above disappearing, although their scars may remain. The child's subsequent development is frequently impaired, and it often retains an almost pathognomonic facies.

After the first year, any of the tertiary phenomena which appear in acquired syphilis may develop, but, in addition to these, peculiar manifestations may be produced, especially affecting the teeth, bones, and cornea; deafness from disease of the internal ear is also not uncommon.

The **Teeth** in inherited syphilis are sometimes very characteristic. The temporary teeth usually appear early, are discoloured, and crumble away. The permanent teeth are often sound and healthy, but are sometimes deformed. The central incisors of the upper jaw are those most particularly affected, but the upper laterals and the incisors of the lower jaw may also be involved. Instead of being broader at the crown than at the root, they diminish in size from root to crown, being stunted, and separated from one another by interspaces. The angles of the crown are rounded off, and a distinct notch, forming a large segment of a small circle, occupies the centre (Fig. 40). The enamel is often imperfectly developed, and hence they decay early. Occasionally they may be shaped like a screw-driver, narrowing from root to crown, and with a straight free border. The notched and stunted teeth described above are sometimes known as 'Hutchinson's teeth,' but they are not very commonly seen at the present day.

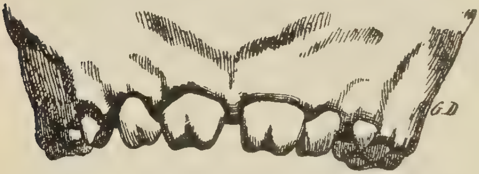

FIG. 40.—HUTCHINSON'S TEETH IN INHERITED SYPHILIS.

The **Bone** affections observed in inherited syphilis will be described in Chapter XXI.

Interstitial Keratitis, or diffuse inflammation of the cornea, usually occurs about the age of puberty, or earlier. It is limited at first to one eye, but the other is almost certain to be similarly affected at a later date. It commences as a diffuse haziness of the cornea, which looks somewhat like ground glass, associated with hyperæmia of the ciliary region. Red areas, or 'salmon patches,' may be produced in the midst of the opacity, due to a new formation of minute vessels. There is no tendency to ulceration, but in protracted cases the anterior part of the eye may bulge forwards, constituting a condition known as 'anterior staphyloma.' The inflammation may spread to the iris and ciliary body. With suitable precautions the cases usually do well, although treatment for several years may be necessary, and some corneal opacity may persist.

The Wassermann reaction in congenital syphilis is usually positive in the earlier more active stages, but in the later it may be absent, as in the late tertiary stage of the acquired variety.

The **Treatment** of inherited syphilis should commence as soon as definite manifestations of the disease are present. The general health must be attended to, and if the mother is unable to nurse the child it must be brought up by hand; *on no account must it be given to a wet-nurse.* Mercury is best administered by anointing the under surface of the flannel belly-band with mercurial ointment, or the same preparation may be rubbed into the soles of the feet every night. This should be continued until all secondary phenomena have disappeared, and advisably until the child is a year old. It is sometimes advisable to replace this by the internal administration of gray powder, gr. ½ or i. t.d.s., with a little sugar. Cod-liver oil may also be ordered with advantage in some cases, and every possible means adopted to improve the general nutrition. When tertiary symptoms appear, iodide of potassium and mercury should be given in suitable doses.

The local treatment of external lesions is conducted according to the rules laid down for the acquired type of the disease.

Yaws (*Frambœsia tropica*) is a disease, rarely seen in Europeans, endemic in various parts of the tropics, and due to a spirochæte, *S. pertenuis*, which is transmitted from the discharge of the sores by direct contact, or indirectly by clothes, flies, or other agents. It is characterized by the development of granulomata, which break down and ulcerate. The primary lesion, often found on the face, is generally single, and its appearance is associated with pain and fever. Secondary nodules appear either in the neighbourhood of the original lesion or elsewhere, and the process goes on spreading, some of the sores healing, and others invading deeper tissues, which may be destroyed and give rise to serious deformities. The condition is closely akin to syphilis, but it is not so certainly influenced by mercury or iodide of potassium. In salvarsan, however, we have an almost certain and very rapid cure.

Tuberculosis.

By tuberculosis is meant a condition resulting from the development within the tissues of the body of certain definite anatomical structures, known as tubercles, and caused by the growth and activity of the *Bacillus tuberculosis*.

Ætiology.—1. It is more than doubtful whether *heredity* plays such an important part as was formerly attributed to it in the production of this disease, which is much more commonly due to direct infection. That there are families in which tuberculosis is specially prone to occur cannot be doubted, but the children are rarely born tuberculous, and only become infected under suitable conditions. Unfortunately, tuberculous individuals often have a considerable degree of philo-progenitiveness, and may be remarkably prolific. Although tuberculous disease is most frequently seen in children or young people, no age is extempt from its attacks, even elderly people being affected. These senile manifestations differ in no way from those met with in the young.

2. *A depressed condition of the general health*, by lowering the general resistance of the body, is a much more common and important cause of tuberculosis. Thus not unfrequently the trouble starts in children after attacks of the exanthematous fevers, or as a sequela of rickets, whooping-cough, or other childish ailments. Many of them leave an inflamed condition of the mucous lining of the pharynx or intestine, and thus provide a suitable entrance for the germs. Even in adults the debilitating effects of influenza, a

neglected cold, or persistent overwork may be followed by an outbreak of the disease.

3. Still more is this likely to happen if the patient lives in *unhealthy or bad hygienic surroundings*. Hot and ill-ventilated workrooms, dirty dwelling-houses, overcrowded schoolrooms, etc., are themselves harmful by lowering vitality, but they often become hotbeds of infection if once consumptive patients are admitted and contaminate the air by expectorating. This probably explains the terrible frequency with which tuberculous trouble occurs in many parts of the country where one would expect the inhabitants to be particularly healthy—*e.g.*, some of the holiday resorts of Scotland, Wales, and Ireland; unfortunately, the houses are small, dark, often dirty, and so hopelessly devoid of ventilation that, if tubercle bacilli once gain an entrance, they become virulently effective in producing disease. Naturally, tuberculosis is most common amongst the poor, but it is only too frequent in the well-to-do, arising usually from improper feeding and unwise coddling of the children, or from faulty hygiene or carelessness, especially as to judicious clothing, in adults.

4. A *local nidus* suitable for the development of the micro-organism usually exists, although tuberculous infection occasionally follows wounds and punctures in previously healthy parts. Thus, chronically inflamed lymphatic glands form a suitable breeding-ground for the bacillus, as also bones and joints in a state of congestion resulting from slight and often overlooked injuries.

5. The ultimate exciting cause of tuberculosis is the development within the tissues of the *B. tuberculosis* of Koch (Plate III., Fig. 26). They usually occur in the form of slender rods, which are straight or slightly curved; they are about 4 or 5 μ in length and 0·2 or 0·3 μ wide, but sometimes form long *branched* filaments, especially in cultures. These characters differentiate them strongly from most bacilli, and suggest that the organism is in reality allied to the streptothrices, and probably several members of this group may produce the disease. This is interesting in view of the close clinical resemblance between tuberculosis and the other diseases due to streptothricial infections (the so-called actinomycosis). The tubercle bacillus is a typical acid-fast organism, and when stained by the Ziehl-Nielsen method appears in the form of slender pink rods, which are often stained only in part, so that they seem to consist of short red lengths alternating with unstained areas, the whole looking not unlike a chain of very minute streptococci. *In vitro* they develop very slowly, two or three weeks elapsing before growth is visible, and require a temperature approaching that of the body and an abundant supply of oxygen. Many culture media are available, and all are improved by the addition of 3 or 4 per cent. of glycerine. The colonies consist of yellowish, white, or gray scales, which have a dryish look. The tubercle bacillus does not liquefy blood-serum; it is non-motile, has no flagella, and is not known to possess spores.

The question of the identity of human and bovine tuberculosis raised by Koch is still under discussion. Both can apparently cause tuberculosis in human beings, but it seems probable that the bovine variety is mainly responsible for intestinal and surgical forms of the disease—*e.g.*, those including glands, bones, and joints—whilst the human variety leads to pulmonary phthisis and to acute general tuberculosis. Cultural distinctions are readily established by the use of egg media, the bovine variety growing scantily, and the human form abundantly, especially in the presence of glycerine. Inoculation experiments in rabbits also differ, in that human tubercle produces but little effect and rarely kills, whereas the bovine virus is actively fatal.

The organism gains access to the body in one or other of the following ways:

(*a*) Most commonly by *inhalation*. The sputum of consumptives contains vast numbers of tubercle bacilli, and, as drying does not immediately kill them, they frequently occur in the dust and in the air. But little advance will be made towards stamping out this disease until consumptive patients can be prevented from expectorating in public places. Even more important is the fact that in coughing and talking the tuberculous sputum is expelled in a state of very fine division, and the infective particles remain suspended in the air for long periods. It is therefore obvious that the strict enforcement of suitable regulations is necessary for the protection of the public from this disease. Tuberculosis acquired by inhalation usually manifests itself in the form of pulmonary disease, but may appear as a primary affection of the bronchial glands, from which the infection may be disseminated to other organs.

(*b*) By *ingestion*—*e.g.*, of infected milk from cows with tuberculous disease of the udders. This is by no means rare in children, the bacilli entering through the tonsils or other lymphadenoid tissues of the pharynx and invading the cervical glands, or passing through the stomach unharmed and infecting the intestine and mesenteric lymph glands. Examinations of tuberculous material from the cervical glands in 72 cases in Edinburgh resulted in the discovery that in 65 (*i.e.*, 90 per cent.) the bovine bacillus was present.* Facts such as these indicate the crying need for some effective control of the milk-supply of our great towns.

(*c*) By *inoculation*. This is very unusual, and occurs chiefly in pathologists, post-mortem room porters, etc., in the form of a verruca necrogenica (p. 252). A few cases of tuberculous infection from an accidental cut inflicted by a broken sputum cup have been recorded.

The *laboratory diagnosis* of tuberculosis is conducted on one or other of the following lines:

1. By the microscopic identification of the tubercle bacillus after staining by the Ziehl-Nielsen method. This is sufficient when bacilli are present in large numbers, as in the sputum; but when this is not the case (as frequently happens in the urine, pus, pleuritic fluids etc.) it is necessary to have recourse to other methods.

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* Mitchell, *Brit. Med. Journ.*, January 17, 1914.

2. Inoculation of susceptible animals, especially guinea-pigs, is a most delicate test. The material is usually inserted beneath the skin of the groin, and the animal killed in three weeks, when the lymph glands and probably the internal organs will be found tuberculous.

3. Tuberculous exudates differ from many others in that the cell which occurs most abundantly is the *lymphocyte*, and this fact is made use of in the examination of pleuritic and peritoneal exudates, the fluid obtained by lumbar puncture of the spinal meninges, etc. It is useful, but must not be regarded as an absolute test.

4. In some cases a portion of the lesion may be excised and submitted to microscopic examination, which should include a search for bacilli, since other infections may give rise to lesions indistinguishable microscopically from tuberculosis.

5. *Tuberculin* (as originally prepared by Koch) is obtained by filtering off the bacilli from a glycerine-broth culture of the organism and suitably diluting the filtrate, which obviously contains merely the exotoxins. It has been, and still is, used as a *diagnostic* agent. When injected into a healthy person, it produces no effect, but in tuberculous persons a sharp rise of temperature occurs in a few hours. The test is not altogether devoid of danger, and should never be used unless one is certain of the absence of a secondary infection, *e.g.*, with streptococci. Two modifications of the test are, however, useful. In *Calmette's reaction* a drop or two of diluted tuberculin (1 in 100 or 1 in 200) is dropped into the conjunctival sac. In tuberculous patients this is followed by mild conjunctivitis, which commences in a few hours, and has usually passed off in twenty-four. The test is somewhat dangerous, cases of severe conjunctivitis, corneal ulceration, and even loss of the eye, having followed its use. A safer procedure is that known as *Von Pirquet's skin reaction*, which is apparently free from danger. It consists in inoculating a small superficial scratch with a drop of 20 or 25 per cent. tuberculin. The reaction consists in the development in from twenty-four to forty-eight hours of a small papule surrounded by a ring of hyperæmia. This test is certainly of great value in children up to twelve years of age, but of course the tuberculous deposit may be of a quiescent character. As a *therapeutic* agent the original tuberculin failed signally, and has been replaced by many other types which are more hopeful (p. 184).

6. The *opsonic index* is sometimes of value in diagnosis (see p. 24). In a healthy individual it ranges between 0·8 and 1·2, and figures above or below that limit are highly suggestive; whilst considerable variations, even from day to day, are very characteristic of progressive tuberculosis.

Pathological Anatomy.—The characteristic lesion is the *miliary tubercle*, a cellular mass 2 or 3 millimetres in diameter, and when isolated readily visible to the naked eye. When young and in course of active evolution, tubercles are soft, translucent, and of a gray colour; after a time they undergo fatty degeneration and become yellowish and opaque. It is often impossible to recognise them macroscopically, since when closely set they fuse together.

A typical fully-formed tubercle without retrogressive changes can be best studied in sections from the meninges in tuberculous meningitis, or from the liver or kidney in a case of general tuberculosis. In the centre of the mass there is a giant cell* (Fig. 41), the diameter of which may be many times that of a red blood-corpuscle. It has usually an oval or circular shape, and its outline is regular; it has many oval nuclei, and these are arranged round the periphery of the cell, their long axes lying in a radial direction. Around the giant cell there is a zone of endothelioid cells, usually oval in shape, and rather larger than a leucocyte; each has a single nucleus, which closely resembles one of the nuclei of the giant cell. Beyond this comes a third or outer zone of small round inflammatory cells, which appear to be identical with lymphocytes. It must be understood that all tubercles do not conform exactly to this typical description. The giant cell, for example, is frequently missing, especially in acute cases, or there may be several cells of this type, though this is unusual. Moreover, the width of the zones varies greatly; in some cases the endothelioid cells may appear to be absent, but can be detected mixed up with the lymphocytes, which extend to the centre of the tubercle.

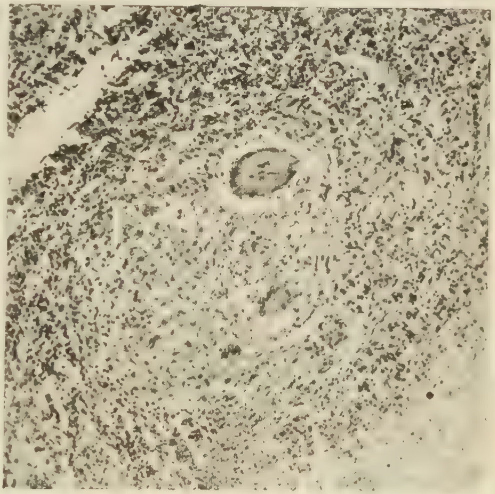

FIG. 41.—MILIARY TUBERCLE WITH GIANT CELLS. (× 120.)

It must be clearly understood that a 'tubercle' in the histological sense is not peculiar to tuberculosis, in the sense of a disease due to the tubercle bacillus. It is simply the reaction of the tissues to an irritant of comparatively feeble activity. Thus it occurs in actinomycosis (see Fig. 45, where a typical histological tubercle is shown surrounding a colony of actinomyces), and may be produced by an unabsorbed ligature, irritants, such as grains of pepper, etc. Hence it is not always safe to make a diagnosis of tuberculosis from an examination of sections, unless the characteristic bacilli are demonstrated.

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* It may be well to notice here that three forms of giant cell occur pathologically, and are of very different significance: (1) Those described above (the tuberculous type), having their nuclei arranged around the periphery of the cell; (2) Myeloplaxes, which occur in myelomata, and have many nuclei grouped irregularly round the centre of the cell; (3) Parenchymatous giant cells occurring in the substance of tumours, especially sarcomata and carcinomata. These have usually a single nucleus, or at most a few, which may be of large size and have no definite arrangement.

The *development* of a tubercle is not yet fully understood. The bacilli appear to gain access to a lymph space or to a small vessel, where they set up an overgrowth of the endothelial cells which constitute the middle zone. The giant cell appears to be composed of a mass of these cells, in which the nuclei have undergone repeated divisions, but the protoplasm has remained unsegmented. The source of the lymphocytes, and whether they are produced locally or attracted from the blood-stream, has been hotly debated. Probably they are formed locally, perhaps by a process of budding from pre-existing endothelial cells.

Miliary tubercles may be embedded in practically normal tissues, but in most cases an inflammatory process can be traced beyond the nodules. It may be of a chronic type, with an increased formation of fibrous tissue; but in the more active forms the intervening structures disappear, being replaced by granulation tissue, which is often œdematous and of a gelatinous appearance. This latter is especially frequent in tuberculosis of the bones and joints. The inflammation also involves the smaller vessels, and particularly the arterioles, the lumina of which may become greatly narrowed, or even entirely obliterated, by a process of endarteritis. True tubercles may also be produced in the vessel walls, but this is much rarer. In either case the vascular affection diminishes the blood-supply of the tuberculous mass (already defective owing to the non-vascularity of the tubercles), and increases the likelihood of degenerative changes, such as caseation.

A fully-formed tubercle may undergo **evolution** along one of the following lines, according to the virulence of the bacilli and the resisting powers of the patient.

1. When the bacilli are but slightly virulent and the patient's susceptibility moderate, the tubercle undergoes **fibrosis**; this is the natural method of cure. The endothelioid cells become spindle-shaped, their nuclei elongated, and the cells are converted into fibroblasts. The periphery of the giant cell becomes drawn out into delicate ramifying processes which penetrate amongst the endothelioid cells, and join with them in forming fibrous tissue. The lymphocytes become less numerous, and ultimately the tubercle is represented by an ill-defined nodule of new fibrous tissue.

2. When the bacilli are virulent and the patient in a non-resistant condition, **caseation** occurs. This is a process of fatty degeneration and necrosis of the nodule, which is transformed into a uniform structureless mass staining only with acid dyes, such as eosin (Fig. 42). It is not often possible to demonstrate bacilli in this cheesy mass; they are there, however, as inoculation experiments show. Caseation occurs in lesions other than tuberculosis, and is due to the action of toxins on the tissues; it is especially common in this disease, since no vessels penetrate the tubercles, which are in consequence badly nourished.

Cure may take place at this stage by a process of fibrosis of the surrounding parts, so that the caseous mass becomes walled in by a zone of fibrous tissue; the cheesy material gradually dries up, and may become calcified. It is possible, however, that living bacilli are present even in dried-up caseous substance, and under suitable conditions recrudescence may ensue, even after an interval of years.

3. In most cases in which caseation is present, the process continues to spread, and involves not only the tubercles, but also the intervening tissues; in this way a cheesy mass of considerable size may be produced. Not unfrequently an exudation of fluid takes place into this mass, and the result is a chronic **tuberculous abscess.**

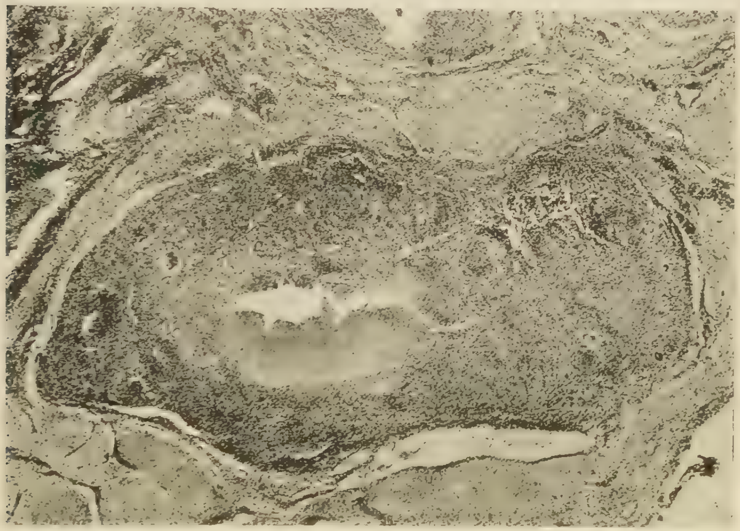

FIG. 42.—EARLY STAGE OF TUBERCULOUS ABSCESS IN LYMPHATIC GLAND (× 30.)

In the centre is a caseating focus on the point of suppuration; outside it, granulation tissue, in which several giant cells can be seen; and external to this a zone of fibro-cicatricial tissue.

Wherever tubercle is deposited, a chronic abscess may form; but it occurs most frequently in bones, joints, and lymphatic glands.

The *pus* from such an abscess consists of disintegrated fatty material mixed with a variable quantity of fluid, so that it is sometimes thin and milky, sometimes so thick that it will scarcely flow through a cannula. It often contains masses or flakes of curdy débris, and on microscopic examination a few lymphocytes may be found, together with large quantities of fatty granular material which will not stain. Tubercle bacilli may be found without much difficulty in the more active cases, but in chronic forms they are often few and far between, or possibly cannot be demonstrated without inoculation experiments. In old-standing cases the presence of cholesterine crystals may be recognised by the glistening sheen or greasy appearance imparted to the pus; microscopically, they appear as flat rhomboidal plates with one corner notched out.

Secondary infection with pyogenic bacteria may also lead to the formation of an abscess in a tuberculous nodule. This is an entirely different process, and one that is usually much more serious for the patient. The pus in such a case may not differ appreciably from the ordinary pus of acute abscesses, and the fact that it contains tubercle bacilli may only be demonstrable by inoculation.

The *microscopic appearance* of a tuberculous *abscess wall* is quite characteristic. The cavity is lined by a layer of gray, yellowish-gray, or pinkish, pulpy granulation tissue, containing miliary tubercles, perhaps undergoing caseation. Its colour and vitality are dependent upon the chronicity or not of the process; the longer the abscess is in forming, the less vascular the membrane, owing to the associated sclerosis of the surrounding structures leading to compression of the bloodvessels, whilst it has been already mentioned that endarteritis always accompanies a chronic inflammation, and helps to render the parts non-vascular. This lining membrane, when necrotic, is but loosely connected with a layer of fibro-cicatricial material, which forms the outer part of the wall, and from which it can be readily detached by the finger or a sharp spoon.

A chronic abscess forms a soft fluctuating swelling which gradually increases in size, and may become painful by exerting pressure on nerves or other sensitive structures. Should it be *superficial*, it will probably come directly to the surface and burst; the pus and caseous detritus will be discharged, and possibly, if the general health is good, the wound may slowly granulate and heal; but not unfrequently the tuberculous tissue left behind prevents healing, and a *tuberculous ulcer* develops. A similar condition is found in connection with mucous membranes, the tuberculous foci starting in the submucosa, and subsequently bursting through the mucous membrane (Fig. 43). Whatever their location, the ulcers are characterized by an irregular and ragged margin with undermined and congested edges; the base is formed by pulpy granulation tissue containing caseous foci (i_1), which must be removed before healing can occur.

On the other hand, a *deep* abscess is likely to burrow along fascial planes, and may become superficial at a distance from its original source, *e.g.*, in a psoas abscess due to tuberculous disease of the spine. The far-reaching extent of these abscesses, the impossibility of dealing adequately with the lining membrane or with the original focus of the mischief, render them most difficult to treat, and fully account for the dread of opening them experienced by surgeons in pre-antiseptic days; for under the best of circumstances a sinus is liable to develop and persist, and without the most minute precautions pyogenic infection is likely to ensue, and then the result is an increased discharge of pus, absorption of the chemical products of putrefaction, aggravation of the original disease, and only too frequently death from chronic toxæmia, associated with hectic fever and amyloid disease (p. 83).

Natural Cure.—A tuberculous abscess, if left to itself, does not necessarily come to the surface. Occasionally one meets with a mass of putty-like consistency lying in front of the spine in the body of a patient who has been cured of spinal disease. This is evidently the desiccated remains of a chronic abscess, the fluid portion having been absorbed, and the solid elements left behind, encapsuled and perhaps infiltrated with lime salts. Such débris can become the seat of recurrent inflammatory mischief years later, when suppuration may suddenly occur, giving rise to what is known as a *residual abscess.* Probably a large amount of cholesterine will be found among its contents. The prognosis of such an abscess is good, and a cure may often be obtained by one tapping and free lavage.

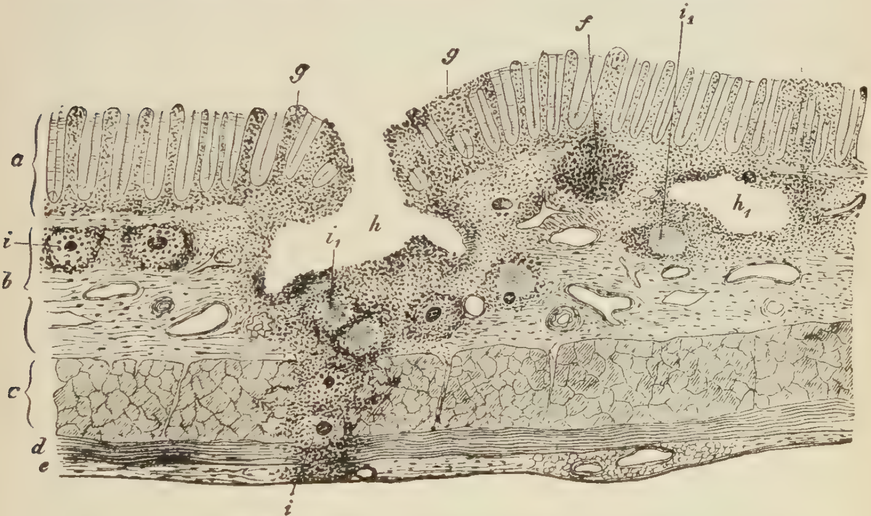

Fig. 43.—Tuberculous Ulceration of Large Intestine. (× 30.) (Ziegler.)

a, Mucosa; *b*, submucosa; *c*, inner transverse muscular coat; *d*, outer longitudinal muscular coat; *e*, serosa; *f*, tuberculous focus in solitary gland; *g*, mucosa infiltrated with cells; *h*, tuberculous ulcer; h_1, focus of softening or tuberculous abscess; *i*, early tubercle, with giant cell in centre; i_1, caseous tubercle.

One of the chief dangers of tuberculous disease is its great tendency to **diffusion,** which is sometimes lighted up by injudiciously vigorous operative interference. It may occur (*a*) *locally,* by direct continuity of tissue, *e.g.*, from the testis by way of the vas deferens to the prostate and seminal vesicles, or by extension along neighbouring lymphatics or bloodvessels; or (*b*) *distant viscera* or organs may become infected, probably by embolic dissemination in the bloodstream. Thus, phthisis is a not uncommon sequence of a similar affection of bones, joints, or lymphatic glands, whilst meningeal tuberculosis is more frequently associated with tuberculous affections of the genital organs. (*c*) Moreover, any tuberculous lesion may lead to *acute general tuberculosis*, in which the disease is scattered widely throughout the body, giving rise to rapid emaciation, high fever of an intermittent type, and usually severe diarrhœa, dyspnœa, and delirium or coma, death ensuing in a few weeks.

Treatment.—When Koch first discovered the tubercle bacillus, a great impetus was given to operative treatment, and some authorities went so far as to maintain that every particle of the diseased tissue must be extirpated with as much care as in the case of cancer. The pendulum has now swung slowly back, and we are relying more and more on the natural powers of repair inherent in the patient, and are endeavouring to maintain and increase these in every way by suitable general and local treatment, reserving operative measures for the comparatively small class of cases which resist such treatment, or to the larger class where such conservative treatment, for various reasons, most often financial, cannot be carried out.

1. **General Treatment** consists chiefly in giving the patient an abundance of fresh air, as free from germs as possible. For surgical cases residence by the seaside, especially in bracing places, is usually recommended. Equally good results will often follow residence in hilly districts, provided that they are not too heavily wooded, that there is plenty of sunshine, and that the soil dries quickly after rain. Failing seaside or country, it is wonderful what exposure to the air in suburban gardens or even on town roofs will do. The patient must be kept warm and well wrapped up, and given an abundance of nutritious food, such as milk, cream, and eggs, in addition to fresh butcher's meat (not too much cooked), fat bacon, and other commodities which tend to increase the patient's weight. The weighing-machine must be consulted weekly, and a steady increase in weight is the best possible prognostic sign. The amount of exercise must be strictly limited so as to conserve the patient's energies towards the cure of his disease, and in this connection it is well to point out that prolonged rest in a spinal carriage is suitable for many conditions other than disease of the spine or of the lower extremities. The internal administration of cod-liver oil, the phosphates and iodides of iron, organic preparations of iodine, guaiacol, arsenical preparations, and other tonics is also indicated.

As already mentioned, many forms of *tuberculin* have been introduced since the failure of Koch's original variety as a therapeutic agent, most of them involving the trituration of the bacilli so as to include the endotoxins. Thus, Tuberculin O was prepared by grinding up the dried bacilli from young cultures, adding water, and centrifugalizing; the clear fluid thus obtained was the tuberculin. Tuberculin R (TR) was prepared by repeating this process until no solid residuum was obtainable, and mixing all the fluids (except the Tuberculin O). A ' New Tuberculin ' has also been prepared, consisting of a suspension in glycerine and water of the ground-up substance of dried bacilli. The human and bovine forms are both prepared in this manner, and a combined variety is also obtainable (=Tuberculin PTO). Opinions vary much as to the exact dosage of patients in different forms of tuberculous disease, but as a rule in surgical cases small doses should be utilized. In a child 0·00001 milligramme given hypodermically might be employed to start with, increased gradually up to 0·001 milligramme, whilst an adult may start with a dose of 0·0001 or 0·0002 milligramme. It may also be administered by mouth, and seems to act quite well. The result may be controlled by observations of the opsonic index, but usually the temperature, pulse, and weight will be sufficient guides as to the good or bad results. The injections should not be repeated under ten or fourteen days, and should never be attempted when a mixed infection is present. In some cases good results follow, but in many the effect is disappointing, and in all its use must never supersede the hygienic and surgical measures required in the treatment of the disease.

2. **Local Treatment (Non-operative).**—In the first place all tuberculous foci must be kept free from irritation, whether extrinsic or intrinsic. Thus, wherever possible the affected part must be maintained at *rest*, both from movement and pressure. Joints should be immobilized by plaster of Paris or suitable splints; the effect of the weight of the body minimized by recumbency or other means when the disease affects the spine or lower extremities; a tuberculous testis should be supported by a suspensory bandage, etc. The advent of a mixed infection must be carefully guarded against, if possible, and especially in connection with lymphatic glands. A patient with glandular trouble in the neck should be carefully treated for any peripheral septic lesions, such as sore lips, dirty teeth, impetigo capitis, or otorrhœa; enlarged tonsils and adenoids should also be removed, inasmuch as bacteria are often lodged in the crypts of the former or between the lamellæ of the latter.

These measures may be supplemented by counter-irritation—*e.g.*, blisters, iodine paint, or Scott's dressing, and Bier's method of passive congestion (p. 41). Parenchymatous injections of iodoform, or of some sclerogenic agent such as chloride of zinc, have also been employed, acting probably by determining an increased flow of blood to the part, and thus strengthening the protective mechanism of Nature.

3. **Operative Treatment** is required when the measures indicated above have failed to check the disease, or when accidental complications—*e.g.*, abscesses—develop in the course of the case, or when the disease is so extensive or progressive as to make it inadvisable to trust alone to the natural processes of repair. Obviously, *extirpation* of the tubercular focus, if practicable, is the ideal treatment in all cases, and for some conditions no other treatment need be considered. Thus, in superficial lymphatic glands in the neck excision is the best treatment whenever progress to recovery is delayed or absent. In many other conditions, as in bone and joint disease, total extirpation is practicable by excision or amputa-

tion; but such a proposal involves the consideration of many other questions, such as the operative risk, the possibility of diffusing tuberculous material into the system generally by the necessary manipulations, the possible infection of the wound or surrounding healthy tissues by tubercle, and the degree of post-operative disability that may result. The cure by a local excision is not always certain, and the after-treatment is often very prolonged. On the other hand, Nature's cure may be equally uncertain, possibly less satisfactory, and the chances of dissemination and diffusion are not absent. The final decision as to the advisability of undertaking a radical operation of this type must be made by a careful consideration of (1) the stage of the disease, whether early or late; (2) its position and extent; (3) its character, whether active and progressive, or chronic; (4) the probable resisting power of the patient to the spread of the disease; and (5) the hygienic conditions, etc., under which treatment has to be undertaken.

Partial operations are sometimes required, consisting in cutting or scraping away as much of the diseased tissues as is practicable, swabbing out the cavity thus produced with some powerful germicide, such as liquefied carbolic acid, and dressing the part with gauze soaked in some modifying or antiseptic substance, such as an emulsion of iodoform, the wound being left to heal by granulation. Diseased bones, glands, and sinuses have often to be dealt with in this way, and satisfactory cures may be established after a while. Open-air treatment must be instituted at the same time, or commenced as soon after as possible. Theoretically, it is better to do the operation in the country rather than in town, but, of course, this is not always practicable.

When the patient has more than one focus of disease—*e.g.*, pulmonary phthisis at the same time as disease of some joint, or of the testis—it is often found that no progress is being made towards recovery, in spite of suitable treatment. It then may be advisable to remove entirely one of the foci, if such be possible, when steady, and perhaps rapid, repair will show itself in the other.

The manifestations of tubercle as it affects **special organs** are dealt with elsewhere under the appropriate headings (see diseases of skin, bones, joints, lymphatic glands, kidney, testis, etc.).

The Treatment of Chronic Tuberculous Abscess must necessarily vary considerably according to the position and condition of the part. A superficial chronic abscess is comparatively easy to treat, but one placed deeply, and connected with such an affection as tuberculous disease of the spine, must be approached with the utmost caution, in order to avoid pyogenic contamination.

1. In certain cases of external chronic abscess, especially when connected with lymphatic glands, it may be possible *to dissect out the whole cavity en masse*, and if such be feasible, it is the most satisfactory plan to adopt.

2. When the skin is thin and undermined, and the abscess nearly pointing, it is hopeless to avoid leaving an open wound; and hence the condition must be treated by the *open method*. The cavity is freely incised, diseased tissue scraped away, unhealthy skin removed, and the cavity, if not too large or

deep, treated with pure carbolic acid or chloride of zinc (gr. xl. ad ℥i.), packed with gauze infiltrated with iodoform, and allowed to heal from the bottom. Healing is often slow, if sure; but a tuberculous abscess ought never to be allowed to reach a condition in which it is necessary to leave an open wound of this type.

3. When a chronic abscess is situated deeply and covered with healthy tissues, treatment consists in emptying the cavity of its contents, removing as far as possible the tuberculous lining membrane, and closing up the wound after introducing into the cavity some modifying or antiseptic injection.

In many cases tapping with trocar and cannula suffices for this purpose. The *modus operandi* is as follows: The skin over the abscess is incised, and a large trocar and cannula introduced obliquely so as to allow the contents to escape. The cavity is then washed out with sterilized salt solution (ʒi. ad Oi.) at a temperature of 105° to 110° F., and the abscess wall gently kneaded from the outside so as to detach curdy material and necrotic pyogenic membrane. This is continued until the escaping fluid is nearly clear or only slightly opalescent, and then a suitable quantity of a sterilized emulsion of iodoform in glycerine (10 per cent.) is introduced, and the opening closed by stitches. In this way it is often possible to cure a chronic abscess at one sitting. The treatment is most likely to be efficacious when all active bone or joint disease has disappeared, and residual abscesses are the most favourable of all. The good results are probably due in part to the liberation of iodine and its antiseptic influence over the tubercle bacilli; but the stimulating effect on the tissues in the direction of leucocytosis by the operative manipulations and the injected material cannot be overlooked.

Where the disease is more active, it is often wiser to make an incision into the abscess sufficiently large to introduce the finger. Through this opening diseased bone can possibly be removed and the lining wall scraped, and for this purpose a Barker's flushing gouge is often useful. The instrument consists of a gouge or sharp spoon with a long hollow handle, which communicates by a tube with a reservoir of fluid placed at some height above the patient. During its application the constant rush of water or lotion through the handle clears the gouge and removes the débris. It is admirably adapted for certain cases, but its use needs considerable care, as the sharp edge can readily scrape through an abscess wall or lay open a vein. If much bleeding occurs, the cavity should be irrigated with hot sterilized salt solution. The wounds are subsequently closed after injecting the iodoform emulsion, and an attempt is made to gain immediate healing of the denuded cavity by bringing the sides into apposition by suitable pressure.

Not uncommonly the cavity refills in the course of three or four weeks, and the irrigation may then have to be repeated. The fluid withdrawn on this occasion is often blood-stained serum, perhaps smelling strongly of iodoform. It is possible that in such cases a sinus develops sooner or later, and has to be dealt with by simple drainage.

It is often a matter of considerable difficulty to secure the healing of a *tuberculous sinus*, owing partly to the existence of diseased bone or other trouble at its extremity, partly to defective drainage, and also in part to the existence of tuberculous tissue in its wall; the added presence of a pyogenic infection will still further delay healing. Not unfrequently sinuses of this type burrow widely, and it is sometimes difficult to ascertain the extent of the mischief with a probe. In such cases help may be obtained by injecting the sinus with a paste consisting of bismuth subnitrate 1 part and white vaseline 2 parts, and examining the extent of the trouble by radiography. This process has the advantage of hastening healing of the sinus owing to the chemotactic, bactericidal, and astringent influence of the paste. In acute suppurative lesions, or where large cavities are involved—*e.g.*, in empyema—this proceeding should not be employed, as toxic effects may follow, and even cause death; the removal of the bismuth paste for toxic troubles is hastened by injecting the sinus with warm oil. Of course, all ordinary surgical measures—*e.g.*, removal of diseased bone or foreign bodies, and free exit for discharges—must be provided when necessary

Glanders.

Glanders is primarily a disease of the horse, ass, or mule, which is transmitted to men by direct inoculation, and hence is usually seen only in stable attendants and those brought in contact with such animals. The disease is due to a definite micro-organism, the *Bacillus mallei*, which was isolated about 1882 by Schutz and Löffler, and has since been cultivated outside the body; the experimental evidence as to its being the cause of the malady is quite complete.

In **Horses** and other animals glanders manifests itself by a formation of larger or smaller rounded swellings in the mucous membrane of the nose, which break down and ulcerate, giving rise to a thin, sero-purulent discharge, and perhaps to destruction of the bones and cartilages. The lymphatic glands, especially those under the jaw, early become enlarged, constituting the 'farcy buds' of farriers, and by their ulceration may leave ragged, foul, suppurating sores. The lymphatic trunks to and from the glands are involved ('corded veins'), whilst the lungs and internal viscera may also be infected, and undergo destructive changes. The disease is often chronic, lasting perhaps for years; any undue strain put upon the animal may lead to an acute outbreak, which is fatal in six to twelve days.

In **Man,** glanders generally starts about the hands and face, but occasionally in the nasal mucous membrane. In **acute** cases the incubation period lasts from three to five days, and is succeeded by the occurrence of malaise and febrile disturbance, followed by severe pains in the bones and joints. The site of inoculation becomes swollen and angry, whilst the lymphatics leading from this to the nearest glands are enlarged and inflamed. An eruption of papules, which somewhat resembles those of small-pox, occurs around the primary lesion, on the face, and in other parts of the body; but each papule, as also the primary lesion, breaks down and goes on to the formation of an ecthymatous-looking ulcer. It is not an uncommon feature of these sores, when placed over a bony surface, to involve the periosteum and lay bare the subjacent bone. Similar changes occur in the viscera, muscles, and joints, and these being associated with high fever of an asthenic type may suggest the existence of pyæmia. In such cases death may ensue in seven to ten days.

In **chronic** glanders similar symptoms are met with, but the course is slower; there is little or no fever; the disease is less extensive, and intermissions are not uncommon. Total recovery is stated to occur in 50 per cent. of the cases. It may affect the nasal mucosa, leading to chronic ulceration, but more commonly it appears in the shape of chronic abscesses, which often extend deeply, even down to the bones, and are very difficult to deal with. In one case the disease gradually spread down along the peronei muscles, and in spite of repeated scrapings and the application of pure carbolic acid, the process was only arrested at the point where the peroneus longus disappears into the foot.

It is important to determine the **Diagnosis** as early as possible, in order to undertaken energetic local treatment. The local lesions are distinguished from *small-pox* by the presence of the characteristic bacilli in the discharge, by the fact that they involve the subcutaneous tissues more extensively, and by the absence of umbilication. Chronic cases resemble *syphilis* and *tuberculosis*, but the history of exposure to infection from animals suffering from the disease is most important, as also the result of cultivations made from the discharge. When the bacilli are grown on potatoes, a colony of a yellowish, honey-like character forms in two or three days, which gradually turns to a chocolate-brown colour. Inoculation of the peritoneal cavity of a guinea-pig with some of the secretion leads to acute orchitis in two or three days, the testicles being enlarged and the skin over them reddened; the affection usually runs on to suppuration. Mallein, a sterilized culture of the organisms, may be used for diagnostic purposes in animals, the injection of a minute dose causing a sharp febrile reaction if glanders is present; but it is of no use for diagnosis or treatment in the human subject.

Treatment in acute cases can be successful only when undertaken early, and before general infection has ensued. The local foci should be thoroughly extirpated, either by the knife, or by scraping and applying some active cauterizing agent. The same treatment must be adopted in chronic cases, and may then need frequent repetition.

Leprosy.

Leprosy (*syn.: lepra*, or *elephantiasis Græcorum*) is a general infective disease due to the *Bacillus lepræ*, characterized by the formation of granulation-like neoplasms, which arise primarily in connection with the skin and nerves.

The bacillus of leprosy closely resembles that of tuberculosis, and, like it, is Gram-positive and strongly acid-fast, staining by Ziehl-Nielsen's method. Leprosy bacilli are usually straighter and more uniform than those of tubercle; and when seen in sections of leprous material they are often present in far larger numbers than are the tubercle bacilli in tuberculous tissues; they are usually packed together like bundles of cigarettes (Plate III., Fig. 29). Numerous attempts have been made to cultivate them, and a few doubtful successes have been claimed. All attempts to inoculate animals have failed, and inoculation constitutes the best and most definite test between the two diseases.

Leprosy, though formerly common in this country, is now only observed in imported cases. In Iceland, Norway, Russia, and the East, it is still frequently met with, although the method of segregation of lepers enforced in Norway has greatly diminished the number in that country. It is apparently very slightly contagious. The medical attendants and nurses in leper hospitals rarely contract the disease, and inoculation experiments in criminals have led to negative results. The late Sir Jonathan Hutchinson held strongly that infection only takes place in persons who eat badly-cured or partially decomposing fish. Opinions differ as to whether the disease is transmitted to the descendants, but probably this is not the case.

Symptoms.—Two chief varieties of leprosy exist, viz., the tuberculated, and the anæsthetic or non-tuberculated; but the two are often associated.

Tuberculated or **Cutaneous Leprosy** is the form most commonly seen in Europe. Nothing may be noticed for months or years after exposure to the contagion, and then, after a period of malaise, associated with dyspepsia, diarrhœa, and drowsiness, a distinct febrile attack is noted, lasting for days or weeks; it may be ushered in by a rigor, and the temperature is usually of a remittent type. This is followed by, or associated with, the appearance of shiny, red, hyperæmic spots, which are from the first infiltrated, slightly raised, and hyperæsthetic; they are usually situated on the forehead or cheeks, on the outer side of the thighs, or on the front of the forearms. They may fade away and disappear entirely, and then again become evident, or fresh patches may be developed, and always with febrile symptoms. After a variable period, 'tuberculation' ensues: numbers of little pink nodules form over the site of one or more of the erythematous patches, and these gradually increase in size and coalesce, until possibly they become as large as a walnut or hen's egg, and are then of a brownish-yellow colour. Almost any part of the surface of the body may be invaded in this manner, but the face is especially prone to be involved, and the resulting disfigurement is very marked, a curious leonine appearance being imparted to the features (Fig. 44). The nodules are more or less anæsthetic from the pressure of the infiltration on the nerves, and the ultimate result of the process may vary considerably; resolution sometimes occurs, or the nodules may be transformed into depressed and pigmented cicatrices, or ulceration may ensue. Visceral complications and enlargement of the lymphatic glands follow, any fresh deposit being associated with febrile phenomena. The testes atrophy, and sexual power is lost in both sexes. Death is usually due to septic phenomena, laryngeal obstruction, or disease of the lungs or kidneys; but the patient may live for many years.

The nodules consist of masses of granulation tissue, and scattered through them are numbers of large cells, containing multitudes of bacilli.

Anæsthetic or **Non-tuberculated Leprosy** is the most common form met with in hot climates. The earliest phenomena consist in a certain amount of malaise without appreciable fever, together with sharp tingling or lancinating pains and tenderness along the course of certain peripheral nerves. The ulnar, median, peroneal, and saphenous nerves are those most often affected. This is followed by muscular weakness, running on finally to paralysis, various modifications of sensation, and trophic phenomena, involving at first only the skin, but later on attacking bones, joints, and muscles. Circular yellowish-white patches are observed in the skin, spreading peripherally, and tending to run together, forming large irregular ovals; the border is often raised, and hypersensitive, but the central portions become atrophic, dry, white, and anæsthetic. The anæsthesia gradually spreads, and serious lesions, partly due to trauma, partly arising from trophic changes, result. The muscles atrophy and contract, and give rise to deformity, the hands sometimes becoming markedly 'clawed,' as in ulnar paralysis. Interstitial absorption of the bones of the peripheral portions of the limbs may lead the fingers, toes, and other portions to shrivel and disappear, preceded by ankylosis of the joints. The affected nerves can usually be felt distinctly enlarged and tender.

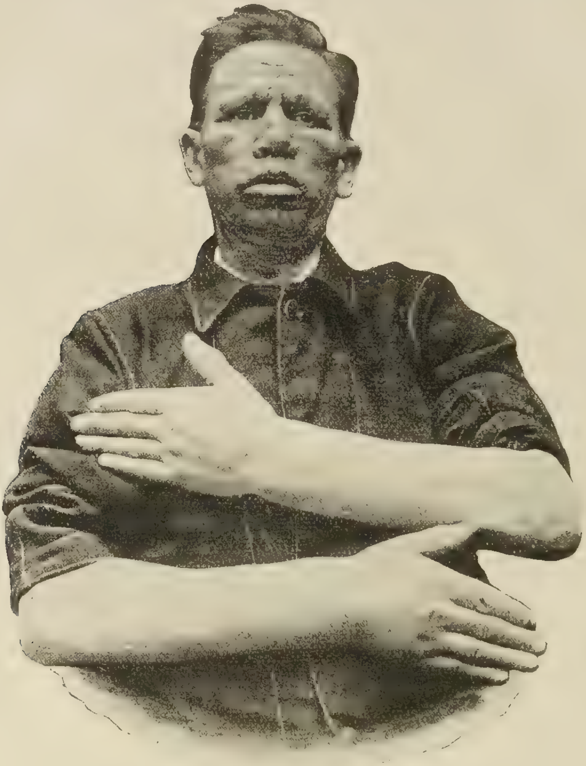

FIG. 44.—LEPROSY. (FROM A PHOTOGRAPH KINDLY LENT BY W. THELWALL THOMAS, ESQ., OF LIVERPOOL.)

The patient had lived as a sailor, and contracted leprosy abroad many years before. The facial aspect is very characteristic, and the forearms are enlarged owing to leprous deposits in the subcutaneous nerves.

Visceral lesions are not so marked in this as in the other form of the disease, and the patient may retain a considerable degree of health and strength, while his sexual powers are not much interfered with. Finally he dies from general debility, or from various complications, but the case may last twenty or more years.

The **Treatment** is still very unsatisfactory. Chaulmoogra oil, administered both internally and externally, is the drug most frequently depended on, whilst intramuscular injections of corrosive sublimate have been employed with some success. Some good results have been attributed to the use hypodermically of Nastin (Deycke), a neutral fat extracted from cultures of the *Streptothrix leproides*, obtained from leprous nodules. It is employed in combination with benzoyl chloride (Nastin B), and acts by withdrawing fats from the lepra bacilli, which are thereby killed. Hypodermic injections cause a reaction of an inflammatory nature and necrosis of the leprous tissue. Amputation of extremities is sometimes useful in late stages of the disease.

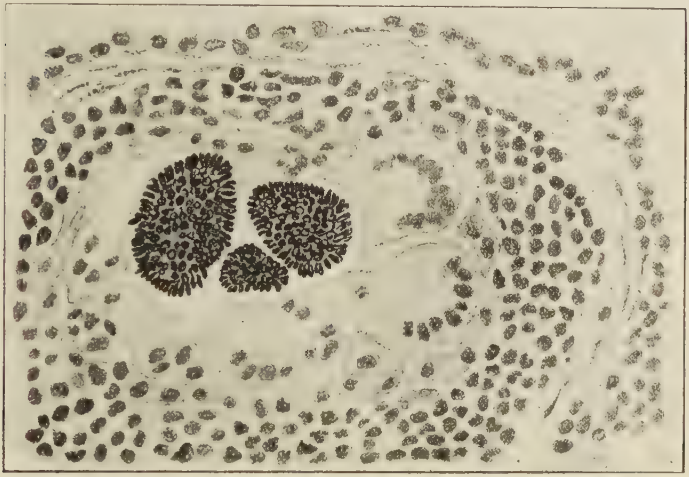

FIG. 45.—BOVINE ACTINOMYCES IN TONGUE. (FROM CROOKSHANK'S 'TEXTBOOK OF BACTERIOLOGY.')

Actinomycosis.

Actinomycosis is a disease of man and cattle, due to infection by various types of a group of streptothrices called Actinomyces (ray fungus). The organisms found in man are rarely identical with those present in the bovine variety, the differences being mainly in the staining reactions.

Actinomycosis in **Cattle** is usually acquired by eating infected barley or other cereals, fragments of which are sometimes found in the primary lesion. It most commonly affects the tongue or jaw, and causes a chronic fibrosing inflammation (the wooden tongue, big jaw, or 'osteo-sarcoma' of cattle). These often suppurate in many places, producing multiple chronic abscesses, which discharge externally and leave a diffuse inflammatory mass riddled with sinuses. The pus from such abscesses contains small yellow or brown gritty bodies (often looking like grains of iodoform) which consist of colonies of the fungi, sometimes undergoing calcareous changes. The structure of these colonies may be made out by crushing the particles between two slides and staining the film thus produced, but is better seen by an examination of sections. Each colony consists of a tangled mass of mycelium, the central portion of which often shows the presence of 'chain spores,' whilst the peripheral part has a definite radial arrangement, from which the organism derives its name. The mycelial filaments which project from the outer portion of the colony are often greatly thickened, and appear in the form of Indian clubs, the narrow ends being pointed inwards (Fig. 45). These 'clubs' were formerly thought to be reproductive organs, but are probably caused by a degeneration of the sheaths of the filaments.

In **Man** the disease is very similar in its clinical characters, and may be caused by a number of organisms belonging to the streptothrix group, so that, strictly speaking, it is not a specific disease. The organisms form colonies in the tissues resembling those seen in cattle, but the radially-arranged clubs at the periphery are difficult to stain, and hence usually appear to be absent (Fig. 46). The cultural characters in different cases are not constant, but all the streptothrices which affect man stain by Gram's method.

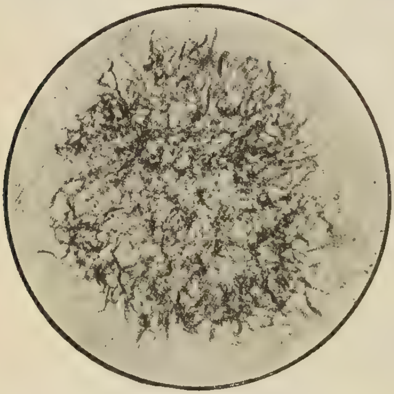

FIG. 46.—COLONY OF HUMAN ACTINOMYCES, AS SEEN IN PUS.

The apparent absence of the radially-arranged clubs' is very obvious.

Actinomycosis is found to be not uncommon when a systematic examination is made of the pus, etc., from all patients treated; when this is not done, a considerable number are diagnosed as tuberculosis or syphilis. It usually occurs in farmers, millers, and others who are brought in contact with grain, and in a few cases infection from these materials may be definitely traced. In many cases the fungus enters the body from a carious tooth or from the tonsil, and the primary lesion is usually somewhere in the region of the mouth. Less frequently it may occur in other parts of the alimentary canal, especially in the cæcum, appendix (causing a condition which may not be diagnosed from ordinary appendicitis in the absence of a microscopic examination), or in the liver, giving rise to a very characteristic reticulated swelling, in which diffuse suppuration may occur. Again, it may be primary in the lung, causing lesions similar to those of tuberculosis, and often giving rise to localized empyemata. The skin may also be affected, but in the majority of cases only by extension from the deeper tissues. Lastly, a few cases of primary actinomycosis of the central nervous system have been recorded.

The structure of these lesions resembles that of a tubercle, except that giant cells are perhaps less frequent (the disease being usually more rapid), and the centre of the nodule is occupied by a characteristic colony of the fungus. At a later period the lesion breaks down and forms pus, containing the granular nodules described above. The disease is very chronic, and has a tendency to spread locally; although not dangerous in itself, it may become so by attacking important organs, or by generalization, giving rise to pyæmic abscesses in all parts of the body.

The commonest site for the primary lesion is close to the angle of the jaw, where it constitutes a cervico-facial growth of tolerably characteristic appearance. At first the mass has a smooth, regular, and even surface, and merges gradually into the surrounding tissues; the skin over it is usually hyperæmic. As time passes, little nodular excrescences, with a peculiar yellowish apex, form here and there on the surface of the tumour, and these finally soften, point, and burst, giving exit to a small amount of glutinous pus, in which the actinomyces can be demonstrated. When all the mycelium has been discharged, the abscess contracts and the wound closes. The cicatrization induced by the constant repetition of this process makes the surface of the mass curiously nodular and puckered (Fig. 47), and this appearance, when present, is almost pathognomonic. At other times sinuses persist, and the affected area may become riddled with them. Trismus is an almost constant symptom in the cervico-facial form of the disease, coming on early, and being apparently independent of the size of the mass or its involvement of nerves.

Treatment consists in the administration of large doses of iodide of potassium (grs. 20 to 30 three times a day) or of some of the organic preparations of iodine, which seem to have almost as great an influence in this disease as in syphilis. This alone may suffice when there is no open wound; but if open sores are present, surgical measures must also be employed. Extirpation of all the infiltrated tissue, either by the knife or by vigorous scraping after opening up sinuses, should be undertaken, and the part freely cauterized: in fact, it must be treated in exactly the same way as a diffuse tuberculous mass. This can, however, only be carried out very partially in the visceral affections, where the disease may prove fatal, not so much from the primary affection as from associated pyogenic complications.

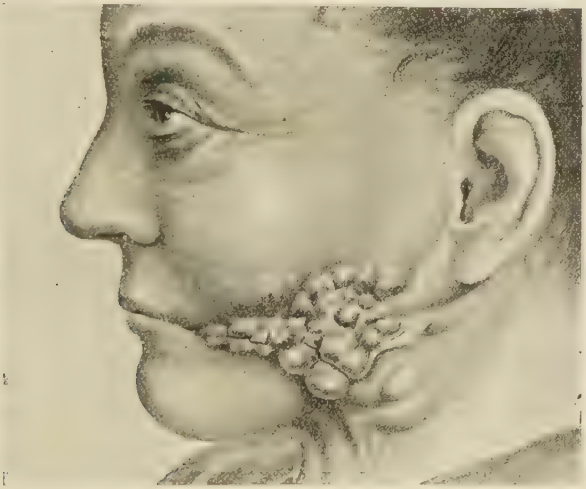

FIG. 47.—CERVICO-FACIAL ACTINOMYCOSIS. (BY KIND PERMISSION OF SIR MALCOLM MORRIS.)

Mycetoma or **Madura Foot** is a condition somewhat akin to, but not identical with, actinomycosis. It occurs in natives of India and some other tropical countries, and is induced by walking bare-footed, infection following some slight abrasion or injury. It is characterized by the development of black or yellow nodules, in the centre of an indurated inflamed area; the nodules break down and give exit to pus, which contains blackish nodules constituted by the organism. Gradually these abscesses spread throughout the foot, which becomes disorganized and distorted, and the disease may even encroach on the leg if neglected. The affection is extremely chronic, and merely spreads by local extension. *Treatment* consists in amputation of the limb, if limited scraping and disinfection are insufficient. The administration of iodides is useless.

CHAPTER IX.

TUMOURS AND CYSTS.

ALTHOUGH the term 'tumour' is often used for any abnormal swelling which may be met with in the body, yet for scientific purposes its application is much more limited. A tumour may be defined as 'a mass of new formation that tends to grow or persist, without fulfilling any physiological function, and with no typical termination.' The fact that it has no typical termination distinguishes it from inflammatory overgrowths, which always lead sooner or later to the formation of fibro-cicatricial tissue or some modification of it; inflammatory growths, moreover, may disappear completely, and often diminish in size temporarily. Pure hypertrophies are excluded by this definition, since they always depend more or less on some increased physiological function, and are composed of an increased development of normal tissues, as, for instance, the blacksmith's biceps. Congenital overgrowth of a limb or portion of a limb also occurs, and is known as 'gigantism'; it cannot be considered a tumour, being merely an exaggerated development of normal tissues.

Ætiology.—The most definite fact known is that in a considerable number of cases (variously calculated at 7 to 14 per cent.) they follow some *injury* or *irritation*, which determines an abnormal development of the tissues of the part. Thus, an adenoma of the breast is often attributed to a blow, and the irritation of a clay pipe may produce epithelioma of the lip. In India the natives of Kashmir wear under their robes an earthenware pot or kangri, suspended from the waist, and containing smouldering charcoal; the heat of this leads to chronic eczema of the abdominal wall, and this is in turn frequently followed by squamous-celled carcinoma. In some cases the irritation may be due to chemical substances such as soot (in the case of chimney-sweeps), tar, or petroleum, all of which occasionally lead to the production of epithelioma in persons brought much into contact with them; except in these cases, *occupation* is not known to exercise any influence in the causation of tumours.

The question of *heredity* as a predisposing factor is still unsettled. It was formerly thought to be of considerable importance, but recent observations and statistics have not strengthened this view.

The *geographical distribution* of tumours has only been investigated in the case of cancer. The result tends to show that the disease is most common in low-lying, damp, well-wooded areas, especially if they are liable to periodical floods, as, for example, the Thames Valley. It also seems proved that certain houses claim more than their average proportion of victims from cancer; this has been taken to indicate an infectious origin for the disease, but other interpretations are possible.

The *age-incidence* varies with the type of tumour. Most innocent forms may occur at any age, though to this rule there are several interesting exceptions—*e.g.*, adenomata of the breast and fibromyomata of the uterus, which grow only during the period of functional activity; and certain osteomata, which arise from ossifying cartilage and continue their growth only during the activity of that structure. In the malignant tumours the age-incidence is better marked. Sarcomata occur at all ages, but are especially common in the first half of life, whilst carcinomata are rare before the age of thirty, and most common after forty.

The effect of *sex* on the incidence of the innocent tumours and the sarcomata is not marked. Women are more liable to carcinomata than males, in large measure owing to the frequency with which this disease attacks the uterus and breast; cancer of the mouth and other portions of the alimentary canal is more common in men.

Many theories have been brought forward to explain the **pathogenesis** of tumours, but the only ones that need be mentioned are the three following: (1) The **parasitic** theory rests mainly on analogy with undoubtedly infectious diseases, and has been formulated chiefly for the malignant growths. There is at first sight a close clinical similarity between cancer and the infective granulomata, especially tubercle; in each there is a primary lesion marked by invasion and destruction of tissues, followed by secondary growths in the glands or internal organs, reproducing the structure of the primary focus. But the analogy is only superficial; the secondary tubercles are due to the carrying of the infective agents (the bacilli) in the blood or lymphatic stream to distant regions, where they are deposited, and continue to grow and give rise to an inflammatory reaction. The secondary nodules of cancer are caused by the transference in the blood or lymph of actual cancer cells derived from the primary tumour, which are deposited elsewhere, and continue their growth undisturbed, in spite of their change of environment. So-called 'cancer parasites' have been described by numerous pathologists, but are now generally recognised as degenerated leucocytes or red corpuscles within the cancer cells, or as portions of nuclei, etc. A few investigators claim to have cultivated blastomycetes from cancers, and to have produced cancers by the injection of the cultures into animals, but these results have not been generally accepted.

Recent researches, though not solving the problems of the origin and nature of cancer, have yielded much valuable and suggestive information. Most of these researches have been carried out in mice, the tumours of which (adeno-carcinoma of the breast, sarcoma, chondroma, etc.) are inoculable into other animals of the same species. The mouse is, however, the only animal in which carcinoma has been successfully propagated (Bashford). It has been possible to transfer mouse-cancer to rats, but the disease quickly dies out.

It is essential that living cells or fragments of tissue should be inoculated if successful results are to follow. The fragment continues to grow in its new host, and, since the transplantations can be carried on (as far as is known) indefinitely, a minute portion may continue to develop in one animal after another until many pounds' weight of cancer has been produced. It would appear, therefore, that the essential character of a malignant cell is its power of indefinite growth and division independently of the surrounding tissues, provided, of course, that these are of suitable nature. The connective tissue of the graft atrophies and disappears. The inoculation of these tumours is not comparable with that of tubercle or other infective diseases. In the latter case, any cells derived from the first animal soon die, but the micro-organism continues to live and produce fresh tissue changes in the new host. In the former, the cells themselves live and divide, and do not induce any cancerous changes in the cells of the second animal. Hence there is some analogy between these cancer cells and the known parasites, which are capable of indefinite life and subdivision in suitable hosts; moreover, if cancer is actually due to a parasite (which appears more and more improbable), this must be contained *within* the malignant cell. Inoculation experiments are followed by a comparatively small proportion of successes, indicating that conditions must be present in the tissues or blood of the host which are favourable to the growth of the tumour. Some tumours are, however, highly virulent, yielding a large proportion of successes, and there is usually an increase in virulence brought about by repeated inoculations.

The question of *immunity* has also been raised. That *natural* immunity exists follows from the facts that not all inoculations are attended by success, and that mice from different localities show very different degrees of susceptibility to the same tumour. That immunity can be *acquired* appears from the observation that a mouse unsuccessfully inoculated with a tumour of low virulence becomes refractory to tumours of great infective power to normal mice.

2. The theory of **fœtal residues** was originated by Virchow's suggestion that in the ossification of cartilage small islets might be left, which subsequently grow and develop into chondromata; the idea was at a later date expanded by Cohnheim to include all tumours. It certainly affords an explanation of some varieties of growth, such, for instance, as the dermoid cysts, which originate in portions of epidermic structures left behind during embryonic development; but it fails to explain the origin of most tumours.

3. Ribbert's theory of **tissue tension** is especially applicable to the carcinomata, and attributes the initial defect to a weakness in the connective tissues in proximity to the epithelial cells, so that

the latter are allowed to proliferate and invade the surrounding structures. The balance of evidence seems decidedly opposed to this theory, although it affords a satisfactory explanation of the frequency of carcinomata in advanced life, when the vitality and resisting power of the tissues may be assumed to be lowered.

Tumours may be divided into two great classes from a clinical standpoint, viz., the benign and the malignant.

Benign or **Simple Tumours** are characterized by their more or less exact limitation, being frequently encapsuled, and by their method of growth. The surrounding tissues are merely pushed aside and compressed by the increasing growth of the part; pain and atrophy are sometimes caused by this pressure. The capsule is formed by an ensheathing layer of fibro-cellular tissue, the outcome of the chronic irritation and inflammation engendered by the growth; hence enucleation is easy, and recurrence uncommon. They are not unfrequently multiple, and may be hereditary; but there is no tendency to produce secondary growths. They cause no cachexia and do not threaten life unless developing in or upon some part whereby the vital functions are impaired.

Malignant Tumours, unless removed by operation, are almost invariably fatal. The following are the chief characteristics of malignancy: (1) The primary growth is usually single, rarely multiple. (2) It progresses steadily and constantly, but with varying rapidity in different cases. (3) The local development is characterized by an infiltration of the surrounding tissues, which are gradually destroyed and replaced by the tumour substance. A capsule is rarely formed, or, if at all, only in the early stages, and thus the limits of the growth are not clearly defined. Moreover, many varieties spread locally along the efferent lymphatics, and hence, although the growth may appear to have been completely excised, recurrences are very common, owing to the non-removal of these invisible extensions of the disease into apparently normal tissue. If a malignant tumour with all its ramifications is completely removed, it does not recur. (4) When a malignant tumour invades the skin, it usually leads to ulceration and is very liable to secondary infection, and then not uncommonly a foul fungating mass results (the *fungus hæmatodes* of the older pathologists). (5) Secondary deposits due to embolic dissemination of the cells of the growth are often found in neighbouring lymphatic glands or distant viscera. (6) Cachexia develops in the later stages, partly due to the pain, partly to the pressure of the growth on important structures, and in part to the absorption of toxic products from the tumour. The patient becomes thin and emaciated, the face drawn and with an expression of pain on it; the appetite is impaired and the skin often sallow and earthy-looking. Pyrexia is usually absent unless ulceration of the growth occurs, as is usually the case in the stomach or intestine; some rapidly-growing sarcomata of bones are also associated with fever. (7) Finally, death ends the scene, after a longer or shorter period of suffering.

The degree of malignancy varies with different tumours. In some the local phenomena predominate, whilst in others the constitutional symptoms are the more important. Thus, rodent ulcer is slow in its progress, and produces no visceral deposits; it destroys life merely by implication of vital parts. Melanotic sarcoma, on the other hand, may produce only a small primary growth, but the most extensively diffused secondary deposits may form in the viscera. The sarcomata are usually disseminated by the blood-stream, and hence secondary growths are not very common in lymphatic glands, whilst the carcinomata spread by means of the lymphatics. Even among the latter considerable differences are manifested; thus, in glandular cancer secondary growths occur both in the lymphatics and the viscera; whilst in squamous epithelioma neighbouring lymphatics are affected, but the viscera usually escape.

As a general rule malignant tumours differ structurally from the innocent forms in deviating more widely from the normal histology of the region in which they develop; thus, a simple adeno-fibroma of the breast approaches more closely to the structure of the normal mammary gland than does an adeno-carcinoma of the same region. This deviation from the normal is called *anaplasia*, and in general the greater the degree of anaplasia the greater the malignancy. It is seen in the structure of the cells as well as in their arrangement, and in highly malignant tumours the constituent cells to a large extent lose their distinctive appearance (*e.g.*, prickle-cells lose their prickles, etc.), and revert to more simple forms. Highly specialized functions are also lost or badly performed.

Classification of Tumours.—The following is a practical scheme of classification, based partly on the structure of the tumour, and partly on that of the tissue from which it originates:

I. **Tumours derived from the Connective Tissues:**
  (*a*) Of embryonic type: Sarcoma.
  (*b*) Of adult type: Myxoma, lipoma, fibroma, etc.

II. **Tumours composed Wholly or Chiefly of Epithelium.**—These may resemble papillæ or glands, or may infiltrate the connective tissue in a wholly irregular way, and hence may be subdivided as follows:

  (*a*) Tumours resembling papillæ:
    Papilloma { Squamous-celled.
      Cuboidal-celled.
      Columnar-celled.
  (*b*) Tumours resembling glands:
    Adenoma { Cuboidal-celled.
      Columnar-celled.
  (*c*) Atypical tumours:
    Carcinoma { Squamous-celled (epithelioma).
      Cuboidal-celled (glandular carcinoma).
      Columnar-celled.

III. **Tumours growing from Endothelium:**
  Endothelioma and perithelioma.

IV. **Tumours formed by the Inclusion of Part of another Embryo:**
  Teratoma.

I. The Connective-Tissue Group of Tumours: (1) Tumours composed of Embryonic Connective Tissue.

Sarcoma (= a flesh-like tumour; Greek, σαρξ, flesh).—A sarcoma is a malignant tumour which consists of a parenchyma, formed of cells which have taken on the power of continued and apparently limitless growth, and of a more or less inert supporting network or stroma consisting of fibrous tissue, bloodvessels, etc. It is characteristic of the sarcomata that these two elements are intimately mingled together, each parenchyma cell being separated from its neighbours by delicate fibrillæ of the stroma; in the carcinomata the parenchyma cells occur in masses or alveoli which are enclosed by, and sharply marked off from, the stroma. Sarcomata are of mesoblastic origin, and the parenchyma cells resemble those from which the connective tissues are formed in the embryo both in shape and in their capacity for continued growth; hence they are often referred to as embryonic connective-tissue cells. Inflammatory new formations are also composed of mesoblastic cells which have assumed the power of growth, and in both cases these embryonic cells may undergo organization into more mature forms of connective tissue, such as fibrous tissue or bone. There is, however, this marked difference between the two: the inflammatory new formations arise as the result of a definite irritant, and cease to spread when that irritant ceases to act; whereas the sarcomata usually arise without apparent cause, and continue to spread indefinitely.

A sarcoma may at first be well defined or even encapsulated; but many forms from the first, and all later on, infiltrate the surrounding tissues, replacing them with their own particular structure, a process which can be well observed in sarcomata of muscles. The *blood-supply* is very abundant, and, indeed, may be so free as to cause the tumour to pulsate. The vessels consist of spaces or clefts within the tumour substance, and are lined merely by the most delicate endothelium; the arteries and veins in the neighbourhood are much dilated. Interstitial hæmorrhage is frequent, owing to the thinness of the vessel walls, and cysts may in this way be produced. *Dissemination* is usually dependent on the relation of the tumour to the veins. As already stated, the veins communicate with spaces hollowed out of the tumour substance; into and along these the sarcomatous tissue may burrow, until the apex of this intravascular growth projects into the lumen of a vessel in which the blood is freely circulating. It may be detached by some slight mechanical injury, and is then carried away as a malignant embolus; if a large portion is set free, as in sarcoma of the kidney, it may lodge in the right side of the heart, or in the lungs, and cause a fatal result. Smaller emboli are either detained in the lungs, or pass through into the general circulation, giving rise to secondary growths wherever they are arrested; general visceral implication is often secondary to the pulmonary growths. Occasionally dissemination by way of the lymphatic glands is met with, especially in melanotic sarcoma of the skin, lympho-sarcoma, and sarcoma of the tonsil, testis, and thyroid body, and this in spite of the fact that lymphatics are not known to be present in sarcomata.

The various forms of sarcoma described below have a tendency to become organized into tissues which bear a close resemblance to the normal connective tissues, and tumours in which this process has taken place to a marked extent often receive special names—*e.g.*, fibro-sarcoma, in which the parenchyma cells become organized into fibrous tissue; osteo-sarcoma, in which they develop into bone; chondro-sarcoma; and lipo-sarcoma. The secondary deposits usually resemble closely the parent tumour; thus masses of osteoid tissue may develop in the lungs when the primary growth is an osteo-sarcoma.

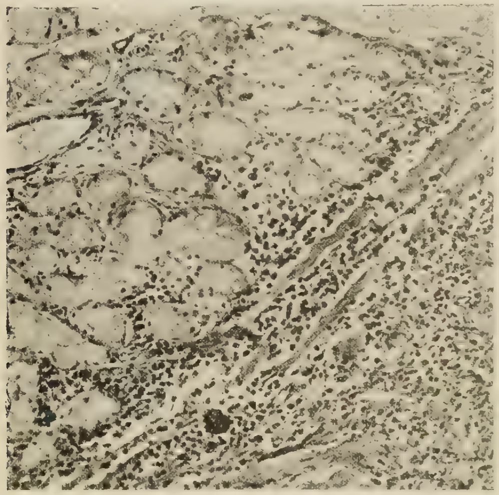

FIG. 48.—SMALL ROUND-CELLED SARCOMA, SHOWING THE ADVANCING EDGE OF THE GROWTH INFILTRATING MUSCLE AND SALIVARY GLAND. (× 120.)

Degenerative changes of a fatty or mucoid type are also apt to occur in the older portions of a sarcoma, giving rise to cystic changes, but the malignancy of the tumour is not thereby affected. Hæmorrhage is frequent into the softer varieties, and calcification is not unfrequent in the more chronic forms.

On naked-eye examination, a sarcoma presents a more or less homogeneous appearance, the colour varying with the amount of the blood-supply, from a grayish-white in the fibro-sarcoma to a deep red in the small round-celled. Its consistency, whether hard or soft, depends on the amount of stroma present; the more malignant are usually soft and may pulsate visibly; the more chronic are often firmer.

Sarcoma occurs most commonly in young and middle-aged people, especially affecting the first and fourth decades of life; it may also be congenital. The degree of malignancy varies considerably, some forms being almost benign, or, at any rate, only locally malignant, whilst others are exceedingly virulent in nature.

Sarcomata are divided artificially into the following groups, depending on the size, shape, arrangement, and character of the constituent cells:

(*a*) **Round-celled Sarcomata** (Fig. 48) usually consist of a mass of small round cells containing a very definite circular or oval nucleus; the intercellular substance is slight in amount, and often homogeneous in character. The mass is very vascular, and may even pulsate; it is soft, like granulation tissue, and usually grows rapidly. It is extremely malignant, infiltrating surrounding parts, and early giving rise to secondary deposits; lymphatic glands are not unfrequently affected in this variety. The small size of the cells is thought to be an indication of the rapidity of development, since they divide before growing to a large size. Any part of the body may be involved, and it may be met with at any age. *Lympho-sarcoma* is a variety of this type in which the intercellular substance is of a delicate reticular nature, corresponding to the retiform tissue met with in lymphatic glands. It grows rapidly, and is exceedingly malignant; it usually starts in lymphatic glands, or in the lymphoid tissue of mucous membranes, and is disseminated by means of the lymphatics. For the clinical characters of lympho-sarcomata, see Chapter XV.

The *large round-celled sarcoma* is an uncommon variety made up of larger cells, which contain one or two large oval nuclei with an abundant protoplasm around. A well-marked stroma is interspersed between the cells, and an alveolar arrangement is sometimes present; it occurs in the same position as the former, but is rather less malignant.

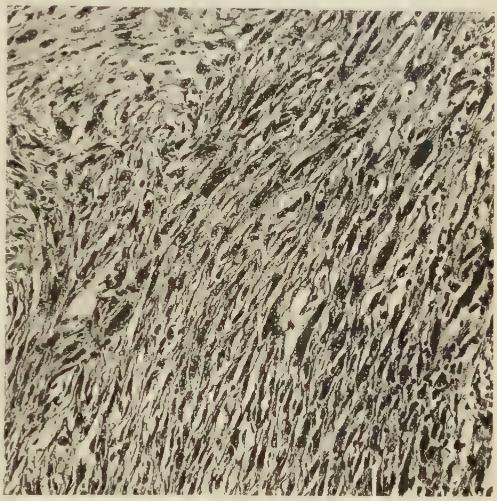

FIG. 49.—SPINDLE-CELLED SARCOMA. (× 100.)
Some of the fibres are running in longitudinal bundles; others are cut transversely.

(*b*) **Spindle-celled Sarcomata** (Fig. 49) consist of large or small spindle cells, which are often arranged in a somewhat fasciculated manner with a greater or less amount of intercellular substance. When consisting of *small cells,* the tumour grows rapidly, and is firmer and less succulent than the round-celled variety. They may originate in any part of the body, but more especially from aponeuroses, fasciæ, tendons, etc., constituting localized growths, which are at first tolerably well defined, but later on invade and infiltrate surrounding parts. When growing rapidly, the cells become less fusiform in shape, and may even approach to the round cell in character, after passing through a stage known as the oval or oat-shaped sarcoma. A few giant cells are often seen in these cases. These tumours, consisting of small spindle cells, are usually very malignant.

In some few cases the cells undergo organization into well-formed fibrous tissue, and the tumour closely resembles a simple fibroma, being well defined. These tumours are known as *fibro-sarcomata* (' recurrent fibroid ' tumours of Paget), and are not uncommon in the subcutaneous tissues. They are on the border-line of malignancy, since they rarely form secondary growths, and often do not return for two or three years after removal. After each operation, however, they usually recur more rapidly, and show signs of greater malignancy, until, after perhaps being removed a dozen times, they recur with all the characters of an ordinary spindle-celled sarcoma.

The *large spindle-celled sarcomata* are softer and of a deeper colour than the former. They grow from the fibrous tissues, and not uncommonly from the viscera. The congenital sarcoma of the kidney is of this nature, though some of the cells become transversely striated, looking like muscle fibres; such tumours are sometimes called ' myo-sarcomata.'

(*c*) **Alveolar Sarcoma** is a variety in which the cells are grouped together in alveoli, separated by a distinct fibrous stroma. On microscopic examination the section closely resembles cancer; but on carefully pencilling it with a camel's-hair brush, it will be found that the stroma sends delicate prolongations between each of the cells. It is quite possible that the majority of these tumours are in reality endotheliomata. They are most commonly found growing from the skin, are occasionally of a melanotic nature, and often very malignant.

(*d*) **Melanotic Sarcoma** is the most virulent of all this group of tumours, because of the early date at which it forms secondary deposits in lymphatic glands and internal organs. It grows from those portions of the body which are naturally pigmented, especially the choroid coat of the eye and the skin. Those growing from the former situation are usually composed of spindle cells, all of which contain granules of melanin; these choroidal tumours are true sarcomata, and have a special tendency to form secondary deposits in the liver. The melanomata of the skin most frequently develop from pigmented moles (Plate IV., Fig. 1). They have an alveolar structure, and were formerly regarded as alveolar sarcomata, but most pathologists now follow Unna in regarding the tumour cells as being derived from downgrowths of the surface epithelium, and classify the tumours themselves as carcinomata. The pigment granules in this form are very unevenly distributed, some lying in the stroma between the alveoli, whilst others are contained in the cells; some portions of the primary tumour are often quite free from pigment, and some of the secondary growths are often colourless, whilst adjacent growths may be absolutely black. The nature of the pigment (melanin) is still uncertain, but the fact that it does not contain iron seems to indicate that it is not derived from hæmoglobin. It may be deposited in the skin of the patient apart from the tumours (melanosis), or may be excreted in the urine.

If the primary tumour is not removed very early, the nearest

PLATE IV.

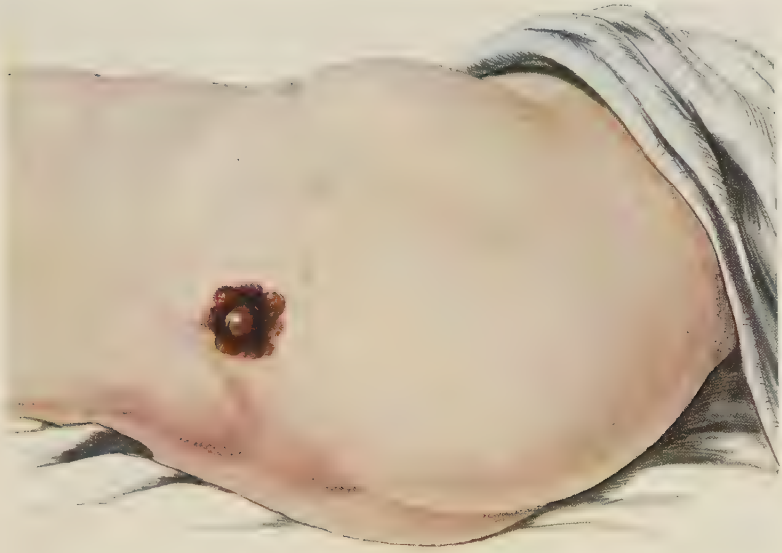

Fig. 1.—Melanotic Sarcoma of Buttock, with secondary coloured nodules in the line of the lymphatics between the growth and the inoperable inguinal glands.

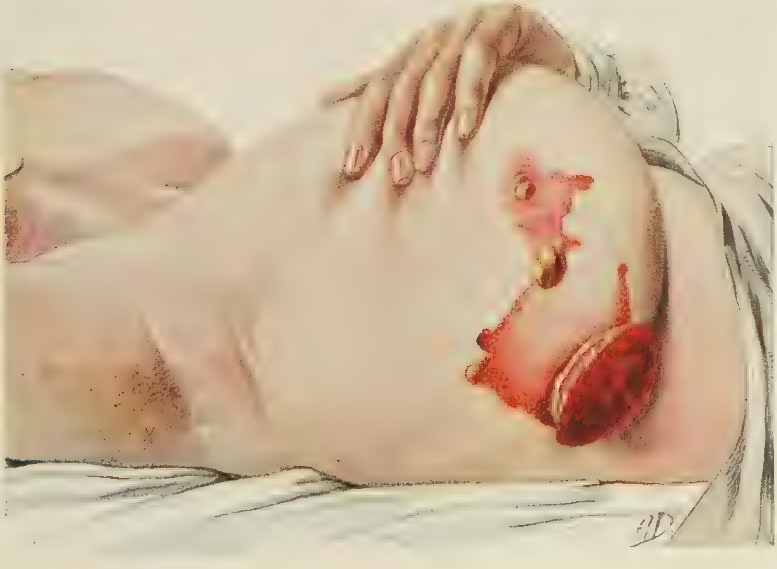

Fig. 2.—Fungating Carcinoma of outer side of the right Breast (Fungus Hæmatodes) with dissemination through skin between the growth and the nipple, and around the nipple, constituting an eczematous-looking patch, somewhat akin to Paget's disease.

[*To face page 202.*

lymphatic glands are soon affected, and secondary deposits in the viscera follow. The original tumour is often not very large, and the secondary deposits are frequently characterized by their number rather than by their size, scarcely an organ in the body being free.

Of late years a more benign type of cutaneous melanosis has been described, and is now well recognised by dermatologists. It usually spreads from a congenital mole as a deeply pigmented patch, which may extend over an area of several square inches, and presents at first no sign of induration or infiltration; in this stage microscopic examination reveals no change in texture except pigmentation of the deeper layers of the cutis vera. Sooner or later, a tumour develops in the centre of this patch; it is not very rapid in its course, but if left alone will finally become disseminated. In treating this type of melanosis, it is essential to remove every portion of pigmented tissue as well as the tumour.

The **Treatment** of sarcoma consists in its removal as early and completely as possible. This may be a simple matter in cases where the tumour is encapsuled, but even then recurrence is very likely to follow unless the capsule is also taken away, and a considerable margin of tissue beyond it. Where, however, the growth is more diffuse, the only hope lies in cutting widely, so as to get beyond its furthest limits, and it may be advisable to remove the skin over it and the lymphatic area leading from it; the prognosis of such cases is very bad.

In cases where, owing to the position of the growth or its extent, complete removal is impossible, a partial operation may be feasible, scraping or cutting away part of the tumour, and stopping the hæmorrhage by the cautery or by packing. *Radio-therapy* may then be employed, sometimes with distinct advantage, in the form either of X rays or of radium. In the former case the rays are applied two or three times a week for an hour or so at a sitting, but care is taken that the same area is not exposed unduly, so as to prevent X-ray burns. In the latter the radium may advisably be buried in the tumour substance for twenty-four hours or more, and then removed (p. 57).

In hopelessly *inoperable* cases somewhat similar measures have been employed as for the similar stage of cancer (*vide* p. 226). Many cures have been recorded from the use of Coley's fluid, which consists of a sterilized culture of the *Streptococcus pyogenes* and *Micrococcus prodigiosus* in bouillon. This fluid is intensely toxic, and the injections, commencing with doses of half a minim, are gradually increased up to 7 or 8 minims or more; severe reaction usually follows, and the surgeon should aim at obtaining two or three such effects each week. The fluid is introduced partly into the abdominal wall, and partly into or around the tumour. If it is going to do any good, the improvement is manifest in a few days, and as the course of treatment proceeds the growth gradually dwindles. The patient is treated for three or four weeks at a time, and then given a rest, as the repeated reactions are very trying, and to persist in this treatment requires much pluck and patience. The results obtained in this country hitherto have been very disappointing, possibly owing to the ineffective character of the Coley's fluid available; but the author has certainly kept one tumour in check for years by this means. The growth is probably a chondro-sarcoma of the ilium, and from time to time the patient comes up to have a short course of treatment on account of a recurrence of the pain, and hitherto improvement has consistently followed the injections.

(2) Tumours consisting of Connective Tissue of Adult Type.

Myxoma.—A myxoma is a tumour consisting of connective-tissue cells, surrounded by and separated from each other by an intercellular substance of a mucoid character; a similar type of material occurs normally in the substance of the umbilical cord. The cells are usually polygonal in shape, and present long branched processes which interlace with those from adjacent cells. The intercellular substance is homogeneous and translucent, containing wandering connective-tissue corpuscles, and traversed by blood-vessels; the density of the tumour varies inversely with the amount of intercellular substance. It is not uncommon for this form of growth to be associated with sarcoma, and hence a thorough and early removal of the mass is always advisable.

Myxomata occur as rounded tumours, perhaps lobulated, in the neighbourhood of mucous membranes—*e.g.*, the face, intestine, and bladder; they also grow in the sheaths of nerves, and are the commonest form of simple tumour of the spinal cord.

Lipoma.—A fatty tumour is an overgrowth of fibro-cellular tissue infiltrated with fat. On microscopical examination it differs in no respect from ordinary adipose tissue, and is not very freely supplied with bloodvessels.

When **localized** (Fig. 50) it forms a tumour, soft and semi-fluctuating in consistence, rounded and lobulated in outline, and if occurring in the subcutaneous tissues, the skin becomes dimpled on moving it from side to side, owing to the fact that fibrous trabeculæ pass from the capsule to the skin. The growth is usually encapsuled and freely moveable; but if exposed to pressure or friction, as when situated on a man's shoulder and rubbed by the braces, it becomes firmly adherent to surrounding structures. Such growths are either single or multiple, in the latter case perhaps occurring in hundreds, and are most commonly found about the trunk or the upper extremities.

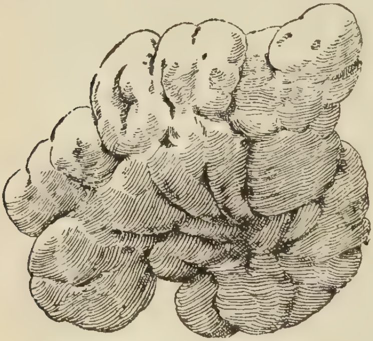

Fig. 50.—Lipoma, showing Characteristic Lobulated Outline. (From King's College Hospital Museum.)

Occasionally subcutaneous tumours become pedunculated and pendulous, especially about the upper part of the thigh.

The *diagnosis* of a subcutaneous lipoma from a chronic abscess is made by noting that in the former there is a defined outline of a lobulated character, that the edge slips away on making pressure over it, and that the skin dimples on moving the growth from side to side. In a chronic abscess the swelling is less defined in outline, has a shelving margin, and the skin is either quite free or adherent over a considerable area. Fluctuation is present in both, since fat at the temperature of the body is fluid.

Deep intermuscular lipomata occur, and the diagnosis is often uncertain, since their mobility and lobulated outline are masked by the superjacent tissues; they have even been mistaken for sarcomatous growths. Still more difficult of recognition are those known as **Parosteal Lipomata,** growing from the outer surface of the periosteum. They are often congenital, and appear as soft swellings, lying beneath the muscles in close proximity to a bone and suggesting the presence of a chronic abscess.

A **painful lipoma of the foot*** has been described (Tubby) as occurring on the inner side of the sole, causing great pain on walking and simulating flat-foot. Removal by operation is necessary, and must be very thorough, if recurrence is to be avoided.

Pericranial Lipoma is of a somewhat similar nature. It is usually congenital in origin, and the cranium may be hollowed out beneath it. An angiomatous element is sometimes present in these growths (nævo-lipoma).

Localized overgrowths are often met with in the subperitoneal fatty tissue, constituting **Subserous Lipomata.** They occur not unfrequently in the lower part of the abdomen, and may extend into the inguinal and crural canals. By their traction a process of peritoneum may eventually be drawn down, and a true hernia produced. A similar condition occurs in the anterior abdominal wall, small pedunculated masses of fat projecting through congenital or acquired openings in the linea alba or linea semilunaris; these are known as **Fatty Hernia of the Linea Alba,** and are often painful.

Occasionally the connective-tissue basis of a lipoma undergoes modifications; *e.g.*, it may become increased in amount, and fibrous in character; it may be associated with a myxomatous element, or even become sarcomatous. For nævo-lipoma, see p. 355.

By the term **Diffuse Lipoma** (Fig. 51) is meant a fatty infiltration of the subcutaneous tissues of some region of the body, particularly beneath the chin and at the back of the neck, and more rarely in the pubic region. These growths are often multiple and almost always symmetrical. They usually occur in men who drink beer freely and take but little exercise. Their size sometimes diminishes on limiting the amount of alcohol and making the patient do physical work.

In some of these cases the term 'diffuse' is not strictly merited, as the growths are in reality limited, but the limitations are difficult to define in the midst of the surrounding fat. They have a considerable tendency to burrow, and by their pressure on important organs may sometimes lead to serious symptoms.

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* *American Journal of Orthopædic Surgery*, May, 1909

A somewhat different type of fatty overgrowth is met with generally in women about the climacteric, in whom masses of fat accumulate in various parts of the body, associated with, and perhaps preceded by, severe pain of a neuralgic type, constituting the condition known as **Adiposis dolorosa** (Dercum's disease). There is but little doubt that the affection in a manifestation of hypothyroidism, since the thyroid body is usually deficient and the mental state dull, whilst the administration of thyroid extract is beneficial. Somewhat akin to this is the deposition of subcutaneous fat together with loss of function or atrophy of the genital organs associated with absence or destruction of the pituitary body.

The **Treatment** of lipomata consists in their removal. When they are loosely encapsuled, this is a very simple matter, all that is required in many cases being to squeeze the mass forwards between the thumb and finger, making the skin tense over it, and then to incise the capsule freely, when the tumour almost jumps out; but if there are many adhesions it may not be so easy. In the *diffuse* forms dietetic and hygienic measures should first be tried, and possibly the prolonged administration of thyroid extract (grs. 5 every night) will suffice to diminish their bulk. Should an operation be required, it is well to cut through the whole thickness of the tumour at once, and deal with each half separately, dissecting it away from its deep attachments.

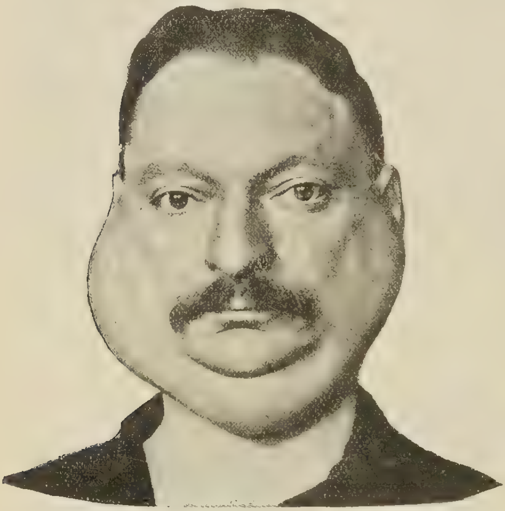

FIG. 51.—DIFFUSE LIPOMA.

Fibromata consist of overgrowths of fibrous tissue; they were formerly divided into two groups, the **hard** and the **soft**, and although there is no essential difference, it is a useful clinical distinction.

The **Hard Fibroma** is composed of firm dense tissue, which creaks on section with the knife, the exposed surface showing numerous trabeculæ of glistening fibres, similar in character to those met with in a tendon (Fig. 52). Microscopically, interlacing fibrillæ are seen, which are sometimes arranged concentrically around the blood-vessels; there are but few nucleated cells in the more slowly growing tumours. The vascular supply is somewhat defective, although dilated veins are often present in the capsule, and sometimes in the substance of the mass; these, if opened by ulceration, may lead to profuse hæmorrhage. Hard fibromata are met with in the form of *epulis, keloid, fibrous polypus of the naso-pharynx,* and not uncommonly in the sheaths of nerves.

Soft Fibromata develop as localized overgrowths of the subcutaneous fibro-cellular tissues, and may be rapid in their onset, and then somewhat resemble a sarcoma, or slow in their growth, approximating more to the type of a lipoma. Sometimes they become more or less pedunculated, constituting what is known as a *molluscum fibrosum,* and then may appear as rounded smooth-topped nodules, or may be pink in colour and covered with somewhat corrugated skin, looking like a nipple, or may develop into large pendulous folds. In the latter instance the condition is usually a manifestation of neuro-fibromatosis (p. 213).

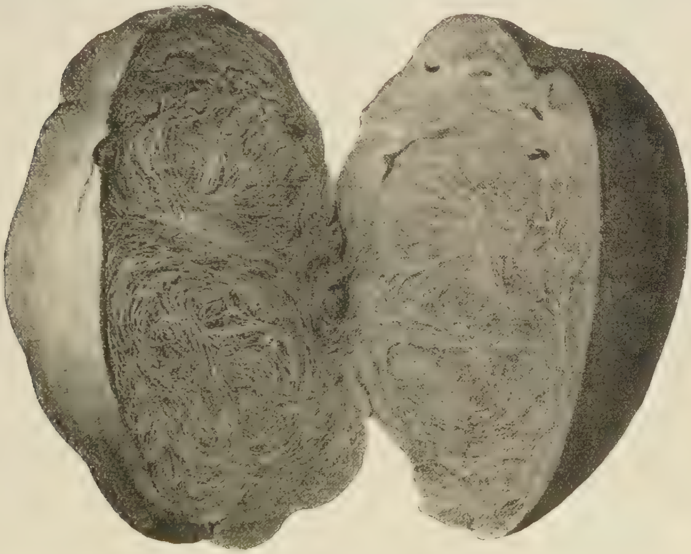

FIG. 52.—SECTION OF HARD FIBROMA. (ROYAL COLLEGE OF SURGEONS' MUSEUM.)

Chondroma.—Cartilaginous tumours grow in connection with either bone or cartilage. They consist of hyaline cartilage, which instead of being uniform in texture and devoid of vessels, as at the articular ends of bones, occurs in the form of pellets or nodules of varying size, held together by vascular connective tissue, which may even penetrate into its substance. The cells are also less regular in shape than is the case with normal cartilage, and are not arranged according to any definite plan.

Chondromata are liable to become calcified, and even ossified. When large, the central parts may undergo a mucoid change, giving rise to a cavity which, if infection is admitted, becomes exceedingly foul. They are not uncommonly accompanied in their growth by sarcomatous and other elements.

Chondromata of *the smaller bones* are not uncommon, being usually seen in the hands of young people, and are frequently multiple (Fig. 53). The growth commences in the interior, close to the epiphyseal cartilage, and results in expansion of the bone, the hand becoming thereby deformed. Treatment consists in incising the capsule, and scooping out the cartilaginous tissue, a proceeding which may result in defective growth and subsequent deformity. In the later stages, however, amputation is inevitable.

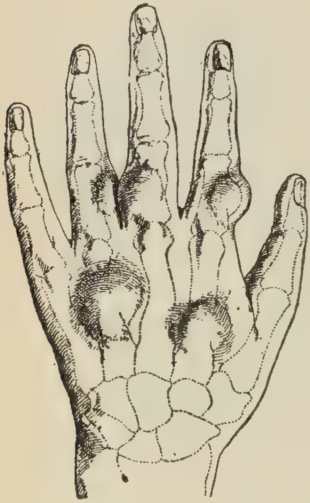

FIG. 53.—MULTIPLE CHONDROMATA OF THE FINGERS.

When growing *from the long bones*, chondromata usually start from beneath the periosteum, and are independent of the epiphyseal cartilage, although it was suggested by Virchow that they originate from a nodule of cartilage displaced from its usual situation during an attack of rickets. They constitute firm lobulated encapsuled tumours, and give rise to no pain, except when they encroach on neighbouring nerves. They often attain a great size. The growth may extend secondarily into the medullary canal, and thus cause expansion of the bone; or it may erode the compact tissue, and lead to spontaneous fracture. Amputation of the limb will probably be necessary, unless the case comes under observation in the early stages, when the tumour can be gouged or scraped away.

Overgrowths of cartilage, known as **Ecchondroses,** occur around the articular cartilages in connection with osteo-arthritis; they also arise from the cartilages and septum of the nose, and from the laryngeal cartilages. Some of the loose bodies which form in joints are of a similar nature.

Osteoma.—Bony tumours are of two chief forms: the cancellous and the ivory.

Cancellous Osteomata are usually met with growing near the articular end of a bone, being derived originally from some isolated portion of the epiphyseal cartilage, which has perhaps been separated from its original connection after an attack of rickets. If such an island be placed near the periphery of the bone, it is easy to understand its development into a tumour, which consists of cancellous bone, capped by a layer of hyaline cartilage, from which it grows (Figs. 54 and 55). It is pedunculated or sessile, and may attain to a large size, leading to considerable deformity. It necessarily develops in young people, and may be congenital. As the individual grows, the basis of attachment may become separated from the epiphysis to an extent corresponding to the amount of growth which has taken place at that spot, or it may still remain attached to the epiphyseal line. As a rule its growth and development cease at maturity, when the cartilage covering it, as well as the epiphyseal cartilage, ossifies. A bursa occasionally forms over the most prominent part of these tumours as a result of friction or pressure, giving rise to the condition known as *exostosis bursata ;* this cavity may communicate with the joint. An effusion of blood or serum into the bursa may be the first evidence of the existence of such a growth. Multiple exostoses are not unfrequently met with, and are then often inherited. The most common situation for such a tumour is the inner condyle of the femur, close to the adductor tubercle (Fig. 54), and it may cause discomfort there by its size, especially when riding. The upper end of the tibia is sometimes affected, and when the growth develops on the inner side, trouble may arise from hitching of the tendons there inserted over the neck of the growth, causing painful locking of the knee. The *subungual exostosis* (Fig. 56) develops as a rounded, cherry-like swelling under the nail of the great toe. It is very painful, and should be treated by removing

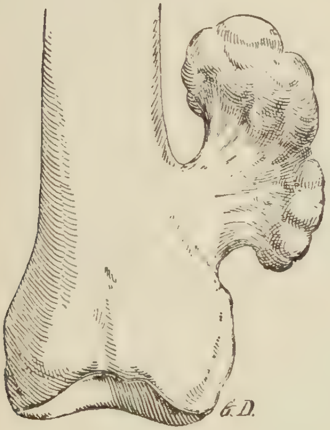

FIG. 54.—CANCELLOUS OSTEOMA OF LOWER END OF FEMUR (SEMI-DIAGRAMMATIC, FROM A SKIAGRAM).

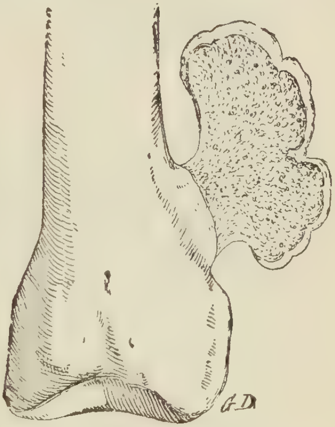

FIG. 55.—THE SAME, WITH OSTEOMA DIVIDED LONGITUDINALLY TO SHOW THE EXTENT OF THE INVESTING CARTILAGE.

the nail, incising the tissues over it down to the bone, and cutting it away with pliers or gouge.

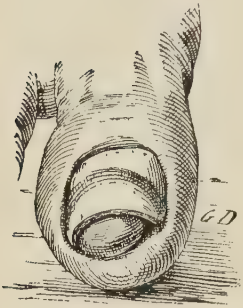

FIG. 56.—SUBUNGUAL EXOSTOSIS. (BLAND SUTTON.)

Ivory Exostoses develop most frequently on the inner or outer aspect of the cranial bones, especially affecting the orbit, external auditory meatus, antrum, and frontal sinus (Fig. 57). They consist of masses of very dense compact tissue, covered by periosteum, from which they grow. They are usually lobulated, and when situated in the frontal sinus, or growing from the under surface of the skull, may give rise to serious symptoms from irritation or compression of the brain or its membranes. In a few cases necrosis has resulted, and they have sloughed out, thus bringing about a spontaneous cure.

Occasionally diffuse overgrowths of the bones of the skull (**Hyperostoses**) are met with, affecting either the calvarium alone, being then probably syphilitic in nature, or the facial and cranial bones, as in leontiasis ossea. New formation of bone also occurs in the substance of muscles and tendons which are exposed to irritation or excessive action—*e.g.*, the tendon of the adductor longus in riders, producing what is known as ' the rider's bone ' (Chapter XVIII.).

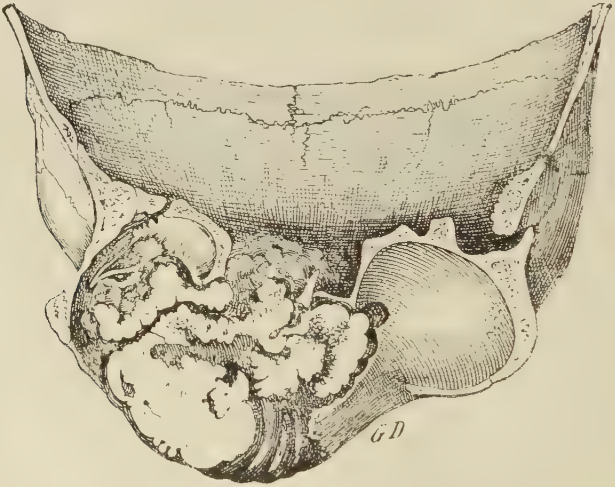

FIG. 57.—IVORY EXOSTOSIS GROWING FROM FRONTAL SINUS, AND ENCROACHING BOTH ON THE ORBIT AND THE CRANIAL CAVITY.
(From Specimen in the College of Surgeons' Museum.)

The **Treatment** of osteomata consists in their removal when necessary. This may be simple in the case of the cancellous osteomata of the limbs, but is sometimes a formidable proceeding when dealing with compact exostoses of the calvarium. The fact that cancellous osteomata cease to grow when the patient reaches maturity explains the rule of surgery that they do not need to be removed unless causing pain or mechanical inconvenience by their size. After careful purification a suitable incision is made, the tumour exposed, and its limits defined. It is chiselled or sawn away from its attachment to the bone, special attention being directed to the total removal of the covering cartilage, since growth continues unless this is completely excised.

Compact osteomata of the cranium may be set free and removed by chiselling away the bone around them, but occasionally a burr driven by electricity is required in order to divide their attachments; they should not, however, be touched unless causing obvious symptoms.

Myeloma.—This tumour, which was formerly described as a myeloid sarcoma, is in reality derived from the bone marrow, and is benign in its nature. It is characterized by the presence of large numbers of multinucleated giant cells (*myeloplaxes*), imbedded in a considerable quantity of round or spindle cells, the intercellular substance being usually of a gelatinous nature (Fig. 58). The myeloid cells vary a good deal in size, but always contain many nuclei, which are not distributed regularly in the periphery of the cell, as in the giant cells of tubercle; they may be regular in outline, or prolonged into numerous interlacing processes, although these latter are usually not very evident. There is also no definite arrangement of cells around them, as in the tubercular giant-cell systems. These tumours are soft in consistency, and on scraping a slimy fluid is obtained. They are very vascular, and may pulsate. Hæmorrhage into their substance is common, giving rise to cysts, filled with serum and a yellowish fibrinous clot. When fresh, the growing edge is of a dark maroon colour on section, and has been

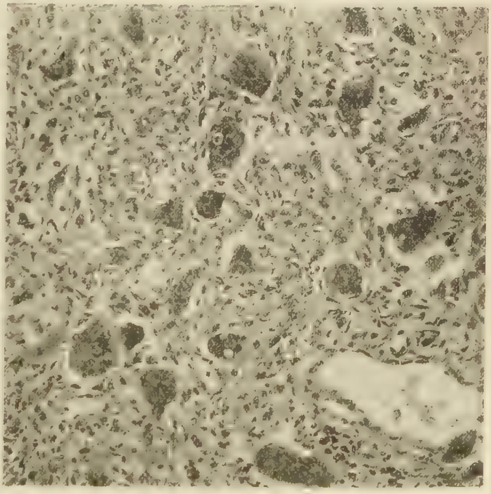
FIG. 58.—MYELOMA, SHOWING THE MULTINUCLEATED MYELOID CELLS (MYELOPLAXES, LYING AMONGST THE MORE ABUNDANT ROUND AND SPINDLE CELLS. (× 100.)

likened to the appearance of a pomegranate; when preserved in spirit, these tumours are always of a characteristic brown colour, owing to the formation of hæmatin. They never give rise to secondary deposits. Their growth is tolerably rapid, and they may attain enormous dimensions. For particulars as to their clinical characters, see Chapter XXI.

Diffuse Myelomatosis, or myelopathic albumosuria, is a condition in which the marrow of the vertebræ, sternum, and ribs, and occasionally of the long bones, is transformed into a structure closely resembling that of the myelomata. The bony tissue is absorbed, and deformity or spontaneous fracture may result. It is associated with the presence in the urine of albumose, which is precipitated at a comparatively low temperature, and redissolved on boiling.

Myoma.—Myomata almost always consist of *unstriped* muscle fibres (**Leiomyoma** or **fibromyoma**), forming rounded and often encapsuled tumours, the cells of which are long and fusiform, and contain a rod-like nucleus. Bundles of these cells are grouped together into fasciculi, which are arranged more or less regularly. The tumours themselves are not very vascular, but vessels of considerable size are found in the capsule. It is often difficult to distinguish these tumours microscopically from fibromata on the one hand, and from fibro-sarcomata on the other. From the former they are known by the fact that individual cells can be recognised, and by the absence of wavy tendinous fibrillæ; from the latter the distinction depends on the facts that other types of tissue may occur in the sarcoma, and that the growing edge is usually more or less embryonic in character, whilst a myoma is of the same structure throughout. Again, in a myoma the bloodvessels have distinct and definite walls, and in a sarcoma they are simply clefts or passages in the tumour substance.

Myomata are met with in the uterus, occasionally in the prostate, and more rarely in the walls of the alimentary canal or in the ovary. Secondary changes sometimes occur—*e.g.*, mucoid softening, calcification, ulceration with profuse hæmorrhage, and possibly consequent inflammation, whilst malignant disease may supervene.

Tumours consisting of *striped* muscle fibres (**Rhabdomyoma**) have been described, but are exceedingly rare.

Neuroma.—**True Neuroma** is seldom met with, only five undoubted cases being on record. It consists of a mass of newly-formed ganglion cells and nerve fibres, which may be medullated or not. It affects children or young people, and usually involves the sympathetic system. The tumours may attain considerable dimensions, are often multiple, and may be quite soft, like a lipoma, or firm. They are insensitive and innocent, and may be freely removed if necessary.

False Neuromata, or those developing in connection with the sheaths of nerves, are more common, and may be described under three headings:

1. **Localized Pseudo-Neuroma,** which may be innocent or malignant, the former being a fibroma or myxoma, the latter usually a

sarcoma. It may project from one side of the nerve, or more frequently the nerve fibres are spread out over it. It moves more freely at right angles to the axis of the nerve than along its course. When developing from a small nameless subcutaneous twig, it is termed a *painful subcutaneous nodule,* and gives rise to intense radiating neuralgic pain, especially when compressed or irritated, or when exposed to cold. A false neuroma growing from a larger mixed nerve (*trunk neuroma*) is less painful, because there are relatively fewer nerve fibrillæ, and the mass is less exposed. A growth on a pure motor nerve, though sensitive, is not associated with radiation of pain. It is uncommon for tumours of this type to cause complete paralysis or anæsthesia, unless they are of a malignant nature. They occur most frequently in healthy adults, and in women a little more commonly than in men.

Treatment.—A neuroma, if painful, should be removed, care being taken, if possible, not to interfere with the continuity of the nerve fibrillæ, the section of the sheath being made in the long axis. If this cannot be accomplished, the nerve must be divided, the growth removed, and the ends subsequently sutured together. In removing a painful subcutaneous nodule it is unnecessary to endeavour to save the nerve.

The *malignant* pseudo-neuroma, as already stated, is sarcomatous in character, and develops at first in the sheath of the nerve, spreading longitudinally, but subsequently involves the tissues around. Clinically, it presents at first the phenomena of a simple growth, but its course is more rapid and painful, and if involving a motor nerve paralysis is induced. The main nerve trunks are usually affected, and it may be possible to treat the case by amputation; failing that, nerve section above the growth may be required to relieve the pain.

2. **Diffuse or Generalized Neuro-Fibromatosis.**—This consists of a diffuse thickening of the nerve sheaths, causing multiple elliptic or spherical tumours, or a generalized enlargement. The growths may be encapsuled and limited, or not; they may be few in number, or hundreds may be present, and they are usually whitish and firm in texture. They originate from the endoneurium of the primary nerve bundles. Any part of the peripheral nervous system may be affected, including the sympathetics, but it is most common in connection with the cranial nerves and the large plexuses of the trunk. The actual symptoms are sometimes very slight, but the tumours may be sensitive to pressure, and some of them, more exposed than the others, may be exquisitely tender. Motor phenomena are rare, and paralysis is usually due to involvement of the nerve roots in the spinal canal, or to the supervention of sarcoma, which is a not uncommon termination. The disease may start at any time during life, and, although progressing slowly, sooner or later terminates fatally. No known *treatment* is of any avail, but should any particular tumour become large and tender, it may be removed.

A **Plexiform Neuroma** is a special modification of this process, occurring congenitally or in young people, and usually involving the trigeminal or superficial cervical nerves; it may be associated with the former condition. The overgrowth is of a softer, more gelatinous type (myxo-fibromatous), and the resulting tumour consists of a plexus of thickened, tortuous, vermiform strands, of soft consistence, held together by loose connective tissue, but easily separable into their constituent elements, which are of a nodulated character, so that the dissected mass looks ' not unlike grains of boiled tapioca on a string ' (Alexis Thomson). The plexiform neuroma is almost always subcutaneous, but often dips deeply between and into the substance of muscles. When limited in extent, the growth may be dissected out, and this is usually required for cosmetic purposes. The final prognosis is rather better than in the former condition, as secondary sarcomatous changes are rare.

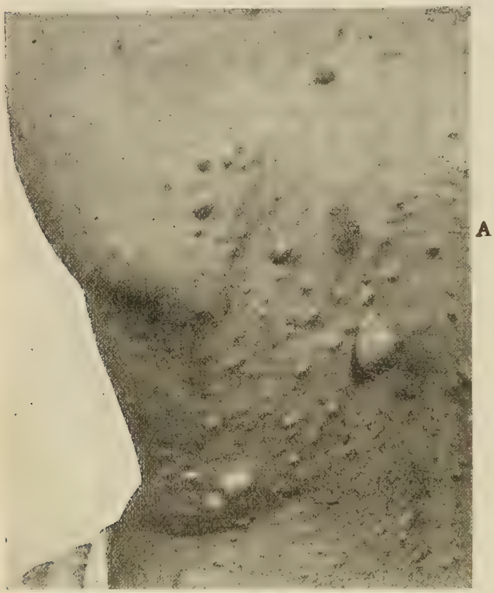

Fig. 59.—Multiple Molluscous Tumours and Pigmentation of Skin (A) in a Case of Recklinghausen's Disease.

(For the loan of this block we are indebted to Dr. F. Parkes Weber.)

In this affection one not unfrequently observes a large development of fibrous growths of the skin, similar to what we have already described as molluscum fibrosum. On careful microscopical examination of specimens stained by Weigert's method, the presence of nerve fibrillæ can be demonstrated in these growths, showing that they are really neuro-fibromatous in origin. So excessive does this overgrowth occasionally become that a form of elephantiasis is produced—*e.g.*, the irregular hyperplasia of the scalp tissues known as a *pachydermatocele*. The association of molluscous tumours with neurofibromatous changes in the nerves and cutaneous pigmentation constitutes the affection known as *Recklinghausen's disease* (Fig. 59).

3. The bulb formed upon the proximal end of a nerve after its division is sometimes described as a neuroma (**Traumatic Neuroma**). It consists of a mass of fibro-cicatricial tissue containing spaces, within which are numbers of newly-formed axis cylinders (p. 372).

Gliomata are tumours arising from the neuroglia of the brain and spinal cord, and occasionally in the retina. Most of the growths occurring in the retina, and supposed to be gliomata, are in reality round-celled sarcomata; the distinction is one of some importance, since true gliomata are never followed by secondary growths. They consist of cells (which may be round, spider-shaped, or spindle-shaped) and of fibres; these occur in varying proportions in different cases, giving rise to the hard and soft varieties. Their colour often closely resembles that of the brain itself, and there is usually no sharp line of distinction between the tumour and the surrounding tissue. They vary greatly in rapidity of growth and in vascularity, but are always benign in nature.

Angioma is the term applied to conditions in which a new formation of bloodvessels occurs; aneurisms and varicose veins are, obviously, not included in this category. For a description see p. 352.

Lymphadenoma and Lymphangioma.—The primary tumours developing in connection with lymphatic glands and vessels are described at p. 368.

Odontoma.—Tumours originating from some abnormal condition of the teeth or teeth-germs are known as 'odontomes.' Bland Sutton, in his work on tumours,* has described seven different varieties, several of which are, however, rarely met with in man. The more important of these are as follows: (1) **Epithelial Odontome.** In this condition, also known as 'fibro-cystic disease of the jaw,' the mandible is most commonly affected. A tumour forms, consisting of spaces lined by epithelium, which are developed as irregular outgrowths from the enamel organ. It occurs most frequently in young adults, and may give rise to a growth of enormous size. (2) **Follicular Odontomes,** or, as they are often termed 'dentigerous cysts,' are produced by the development of a cavity around a misplaced or ill-developed tooth of the permanent set, which often lies horizontally, so that its eruption is impossible. (3) **Fibrous Odontomes** are the result of a thickening and condensation of the connective tissue around a tooth sac. They are most frequently observed in the lower animals, but are also said to occur in rickety children. (4) **Radicular Odontome** is the term applied to a tumour composed of cement, developing at the root of a tooth. It gives rise to severe pain, and may cause suppuration in the surrounding bone. (5) **Composite Odontomata** consist of a conglomeration of the various forms of tissue entering into the formation of a tooth, and developing in the neighbourhood of the jaw. They may be very large, and probably some of the bony tumours described as osteomata of the antrum are of this nature. (See also Chapter XXVIII.)

II. Tumours of Epithelial Origin.

The various tumours grouped under this heading are composed mainly of epithelium, with a variable admixture of connective tissue. They are derived from pre-existing epithelial structures, and vary in the arrangement and character of the epithelium with the site of origin. Epithelial cells can practically be of only three types: (*a*) The spheroidal or cuboidal, in which the three diameters are more or less equal; (*b*) the flat or squamous, in which two diameters are long and one very short; and (*c*) the columnar, in which one diameter is long and two are short. These three forms of cells are found in most of the groups of epithelial tumours. In some the structure conforms more or less to the normal type, and then the growth is probably of an innocent nature, as in the papillomata and adenomata; but when the structure becomes atypical, the tumour is likely to be malignant and of a cancerous nature.

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* Bland Sutton, 'Tumours and Cysts.' Cassell and Co

Papilloma.—This term ought really to be limited to tumours formed by an overgrowth of papillæ, and since papillæ are confined to regions covered with epithelium of epiblastic origin, they are, strictly speaking, only found in the skin and the so-called 'mucous membranes,' which are morphologically of the same nature—*i.e.*, that lining the mouth, vagina, larynx, anus, etc. They consist of the same structures as a normal papilla, there being a central core of mesoblastic tissue (connective tissues, vessels, etc.) covered by squamous epithelium, which may or may not undergo excessive horny development, and, like the normal papillæ, of which they are an exaggeration, they project outwards from the general surface of the body, and never invade the subcutaneous or submucous tissues (Fig. 60).

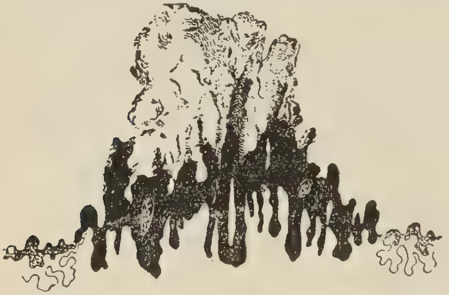

FIG. 60.—SECTION OF A WARTY PAPILLOMA TO SHOW THE ARRANGEMENT OF THE EPITHELIUM.

The normal skin is seen on each side running into the hypertrophied papillæ, over which is heaped up a mass of thickened keratinized cuticle. There is no invasion of the subcutaneous tissues, as in an epithelioma (*cf.* Fig. 62).

The term is, however, often used loosely to indicate a growth composed of a mesoblastic core with an investment of epithelium; thus, we speak of papillomata of the large intestine, although in this region true papillæ do not occur. Hence it becomes convenient to classify the papillomata according to the nature of the epithelium with which they are covered.

(1) Those covered by *squamous* epithelium occur in the skin, mouth, larynx, etc., and consist of bundles of papillæ, which undergo extensive proliferation and frequently branch, forming secondary papillæ. If the epithelium undergoes keratinization, as in the common warts, they become hard, and may constitute horn-like outgrowths. When they occur in moist situations—*e.g.*, between

the toes, on the prepuce, or growing from mucous membranes (except that covering the vocal cords)—this formation of horny substance is usually very imperfect, and the papillomata remain soft. It must be pointed out that many of the squamous papillomata are of infective origin, and not true tumours at all—*e.g.*, the venereal warts, condylomata, and mucous tubercles. There are also some reasons for thinking that warts may be infective and due to the action of a micro-organism. Not unfrequently a papilloma which has become irritated may take on malignant action and be transformed into an epithelioma, a change which would be characterized clinically by the base becoming infiltrated.

The papillomata which develop in the bladder and pelvis of the kidney are covered by many-layered *transitional* epithelium, and usually form long slender fimbriated tufts containing delicate bloodvessels, which readily give way and may lead to considerable hæmorrhage. Not unfrequently they occur in conjunction with malignant growths.

(2) Papillomata covered by *cuboidal* or *spheroidal* epithelium occur in glandular structures, especially in the breast, kidney, etc.

(3) Papillomata covered by *columnar* epithelium are sometimes found projecting into cystic cavities in other tumours, as in the proliferous ovarian cysts and in duct carcinoma of the breast, as also into dilatations of other ducts. The 'papillomata' of the intestine are usually either adenomata or fibromata.

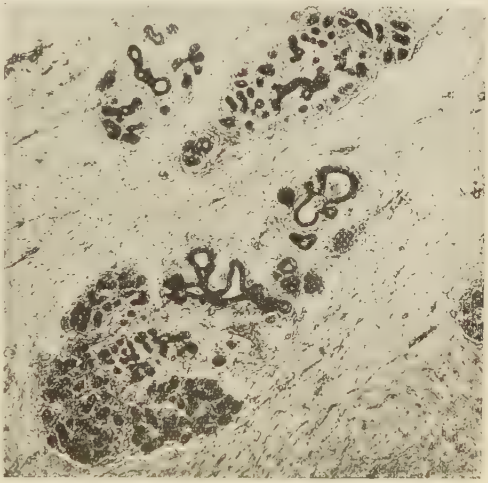

FIG. 61.—FIBRO-ADENOMA OF THE BREAST. (× 30.)

Adenomata consist of new growths arising in connection with secreting glands, and in structure simulating somewhat closely the organs from which they rise (Fig. 61). They differ from them, however, in that they are incapable of producing the character istic secretion, that they are devoid of ducts, and that the mimicry is incomplete, since the alveoli are less perfectly developed, and may be entirely occupied by several layers of epithelial cells. The epithelium, which from the nature of the case is spheroidal, cuboidal, or columnar in shape, does not pass beyond the basement membrane into the connective tissue, and by this lack of infiltration they are distinguished from cancerous tumours. A variable amount of connective tissue is always present, and may be normal in texture, or may manifest various modifications. Adenomata are single or multiple, and usually encapsuled, being merely connected with the original gland by a pedicle, through which the vessels enter. When growing from mucous membranes, they sometimes become pedunculated, as in the so-called polypus recti. The alveoli in some cases become distended with effusion, giving rise to a cysto-adenoma or adenocele, and sometimes the tumour projects into these, constituting intracystic growths. They are free from malignancy, except that occasionally the connective tissue undergoes a sarcomatous change; more rarely carcinoma supervenes, especially in the breast. When of large size, they may cause trouble by compression of important structures. Any glandular organs may become affected with adenoma—*e.g.*, the breast, thyroid body, prostate, testis, etc. They are also found as congenital tumours in connection with the thyroid body, post-anal gut, and possibly the kidney.

Carcinoma.—The *malignant forms* of epithelial new growth are known as ‘ cancers ’ or ‘ carcinomata,’ and are characterized by the appearance of a primary growth, which, by its continued development, infiltrates and destroys the neighbouring tissues, incorporating them into its substance. If superficial, the growth undergoes necrotic changes, resulting in ulceration, which frequently becomes horribly offensive owing to the supervention of a mixed infection. The disease spreads along the lymphatics, and involves neighbouring lymphatic glands, which may also break down, or suppurate, and ulcerate; and finally general dissemination to the viscera may occur, the lungs, liver, brain, and bone-marrow being specially liable to invasion.

Any epithelial surface or organ may be affected by cancer, but it is most frequently seen in parts which are exposed to injury or chronic irritation. In the *male*, the stomach is the organ most frequently affected, and then follow in order the intestines, tongue and mouth, etc. Eighty per cent. of all cancers in the male sex affect the intestinal canal; in the *female*, cancer of the uterus, sexual organs, and breast, account for nearly 80 per cent. of all cases of the disease. It is not very common in early life, but increases in frequency after thirty years, and reaches its maximum incidence between forty and fifty-five years of age.

Cancers are classified as epithelioma, columnar cancer, or spheroidal-celled cancer, according to whether the epithelium from which the tumour is derived is of the squamous, columnar, or spheroidal type. The term ‘ celloid cancer ’ is used to indicate a degenerative change occurring in some forms.

The essential character of a cancerous growth consists in an *unlimited multiplication* of the epithelial cells in the organ or tissue attacked. The cells thus affected lose to a greater or less extent that interrelation which normally makes them grow into glands or other structures, so that in the malignant tumours the epithelia cells form masses which show a varying degree of resemblance to the glands, etc., of the normal part: in general, the greater the malignancy, the greater the anaplasia, until in the most malignant forms the epithelium is arranged in masses or alveoli, bearing not the slightest resemblance to the structure from which it springs. There is also an alteration of the mutual relations between the epithelial cells and the connective tissue of the part. The former take on unlimited powers of growth, but are not (as is the case in innocent tumours and in epithelial proliferation due to irritants or other causes) limited by normal basement-membranes and other mesoblastic elements, but burst through these, producing *infiltration* of surrounding tissues. Columns of epithelial cells can be seen to penetrate into the tissues (Fig. 62), following the lines of least resistance, and usually extending deeply along the lymph-clefts. There is thus no longer a sharp and definite line of demarcation between the epithelial and connective-tissue portions of the tumour, but the two are inextricably blended. The epithelial cells themselves are also anaplastic, losing their more specialized characters, and reverting to simple masses of protoplasm which have lost all powers except that of growth and subdivision. They often differ greatly among themselves in size, character of nuclei, etc., and in rapidly-growing carcinomata numerous mitoses (which may be irregular, tripolar, or multipolar) may be seen.

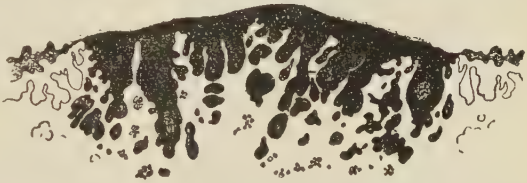

FIG. 62.—SECTION OF AN EPITHELIOMA.

The normal skin is seen on each side running into the growth, which dips down into and invades the underlying tissues. This diagram should be compared carefully with Fig. 60.

Marked changes occur in the connective tissues around the cancer; they are irritated by the growth, and become infiltrated with small round cells (lymphocytes) and plasma cells, which undergo a greater or less degree of organization, leading to the development of a stroma of variable density and vascularity around the epithelial columns. In chronic cases the stroma is usually fibro-cicatricial in type, and contains few bloodvessels; in the more actively growing parts and in acute cases the stroma is comparatively small in quantity, more cellular, and decidedly vascular. When ulceration has occurred, polynuclear leucocytes are usually abundant, and other inflammatory manifestations may be seen; pyogenic bacteria may sometimes be detected in the growth.

Cancerous tumours are not necessarily tender to the touch, but a considerable degree of pain, usually of a neuralgic type, is often complained of, especially in the harder forms, when tissues get dragged upon by the contracting stroma.

The enlargement of the neighbouring lymphatic glands is usually an early and important sign, but it must be remembered that, when the primary growth has a dirty ulcerating surface, the enlargement may be largely due to the absorption of toxins, and treatment directed to cleansing the surface of the sore may lead to a disappearance of the enlargement.

1. **Epithelioma** (*syn.* : **Squamous Epithelioma, Epithelial Cancer**).—By this term is meant a cancerous tumour growing from skin or from those portions of the mucous membranes which are covered with squamous epithelium.

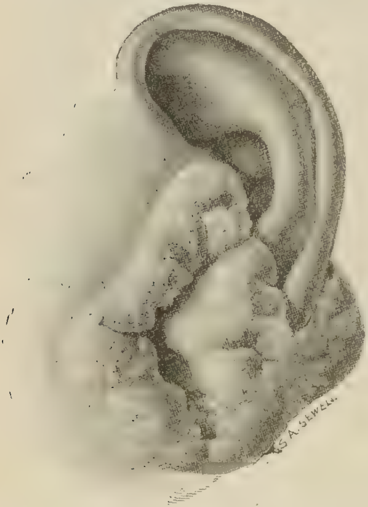

Fig. 63.—Typical Epitheliomatous Ulcer, showing Heaped-up Margins and Deep Central Crateriform Excavation. (College of Surgeons' Museum.)

Epithelioma is usually met with in middle-aged or elderly individuals, occasionally in young adult life. Any part of the skin may be the site of this tumour, as also the mucous membrane of the mouth, pharynx, and œsophagus, and that lining the genito-urinary tract. It commonly results from some long-continued irritation, as in the lip or tongue, whilst upon the penis it is always associated with a long foreskin. Old scars, especially if they become ulcerated, are likely to be invaded, and the disease may supervene on intractable lupus.

Clinically, epithelioma may be looked upon as a *malignant wart*, which not only grows outwards from the surface, but also burrows deeply into adjacent tissues (Fig. 62); sooner or later ulceration follows. Several characteristic forms are described: (*a*) It may occur as a nodular indurated mass, with hard everted edges and central ulceration, giving rise to a somewhat crateriform ulcer (Fig. 63). (*b*) The destructive process may extend equally with the new formation, leading to the appearance of a depressed sore, with sharply-cut edges, closely resembling a rodent ulcer. (*c*) Occasionally the superficial outgrowth is excessive, and the destructive process limited, giving rise to a projecting cauliflower-like mass, which is soft and easily bleeds (*malignant papilloma*). (*d*) A chronic epithelioma is sometimes seen, in which the fibrous stroma contracts and compresses the columns of epithelial cells; the surface is then indurated and wart-like, with but little ulceration, whilst the base is very hard, and the progress of the case much less rapid than in other forms. This form is not uncommon in the lip.

The disease, as a rule, early infects neighbouring lymphatic glands, which become the seat of a similar growth, and, if superficial, sooner or later involve the skin and give rise to characteristic ulceration. As the disease progresses, more distant groups of lymphatic glands are attacked; it is unusual to find this form of cancer disseminated through the internal viscera. The glands sometimes become cystic, especially in the neck, and on cutting into them a thin, turbid fluid like sero-pus escapes, mixed perhaps with white masses of epithelial débris; from time to time similar material is discharged through the resulting sinuses. Ulceration into the main vessels of the neck may

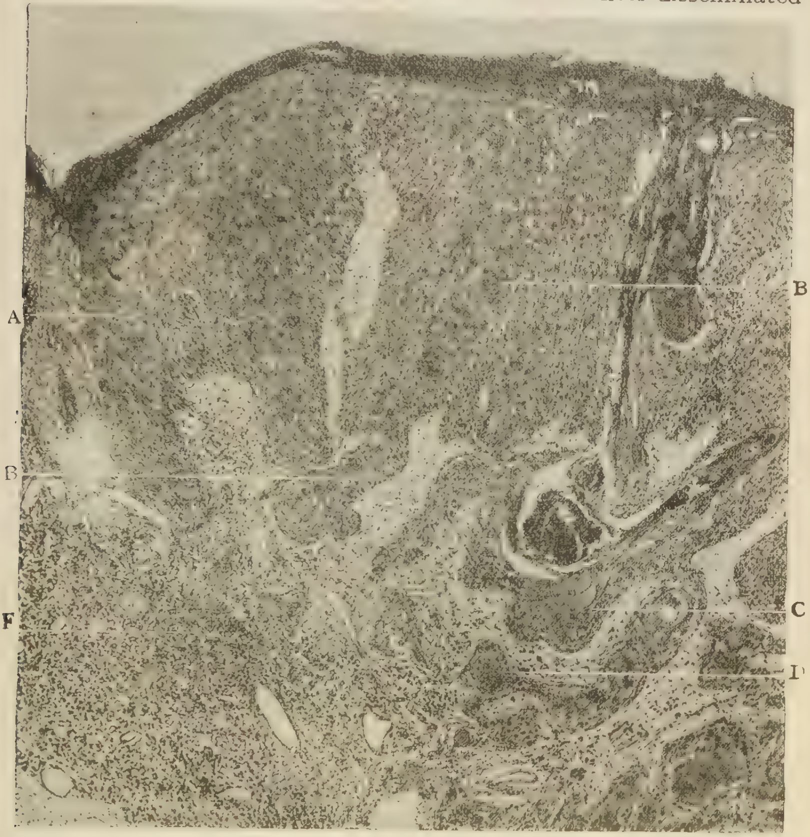

FIG. 64.—EPITHELIOMA OF LIP.

The epithelium at the left-hand margin of the figure is normal, whilst at A the altered appearance of the cells indicates that they have become malignant; at B, C, D, they are growing down into the stroma in irregular columns; B indicates a small cell-nest, and C passes through one half an inch from its extremity. The connective-tissue stroma is inflamed. This is most marked at F.

also follow, and cause death from hæmorrhage; otherwise the fatal event is due to cachexia and exhaustion.

Microscopically, an epithelioma consists of columns of epithelial cells (Fig. 64), ramifying in the subcutaneous tissues, and interlacing freely with each other, so as to produce an irregular network, the meshes of which are occupied by a fibro-cellular stroma, which is frequently infiltrated by an inflammatory exudate of small round cells (largely lymphocytes or plasma cells). The true cancer cells are derived from the prickle-cell layer of the epidermis, but in some rapidly-growing cases the cells undergo so much alteration that the prickles are difficult to find. The cells in contact with the stroma are usually regular, and resemble the basal layer of normal skin; the cells next to this are polygonal in shape, and in the deepest layers may become flattened and undergo imperfect keratinization. This differentiation is best seen in the cell-nests (Fig. 65) which develop in the substance of the columns; they are most common in comparatively chronic cases, and may be absent in the rapidly-growing forms.

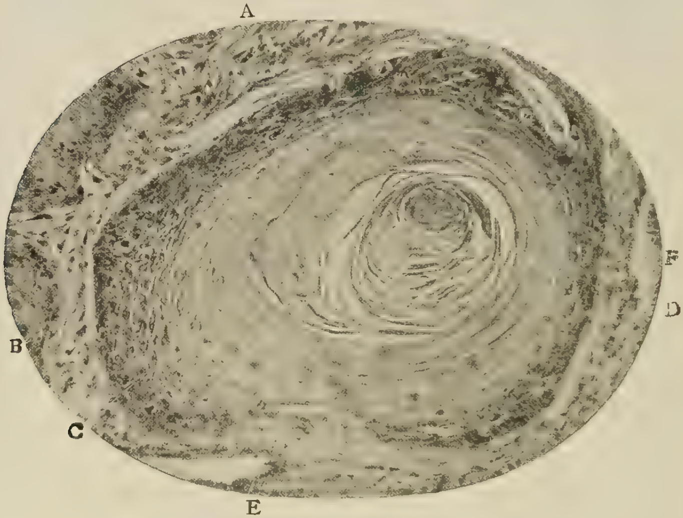

FIG. 65.—EPITHELIAL CELL-NEST, FROM AN EPITHELIOMA OF THE MOUTH.

A, Stroma, with collections of small round cells; B, layer of basal epithelial cells; C, prickle cells, which at D have become flattened; E and F show the final stage, the cells being transformed into badly-formed keratinous scales.

2. **Spheroidal-celled Cancer** usually develops in connection with glands, and may be looked on as a *malignant* form of *adenoma,* bearing the same relation to the latter as does an epithelioma to a benign papilloma. The epithelium of the glandular acini, from which it originates, is not retained by the basement membrane, but travels

beyond it along the lymphatics into surrounding parts, which are transformed into the tumour substance by a process already described. The amount of stroma varies considerably, and according to whether it is abundant or small in quantity, the tumour is hard or soft in consistence, and slow or rapid in growth. To the former type the term *Scirrhus* is applied; to the latter, *Encephaloid*.

Scirrhus is met with most frequently in the breast, but also occurs in the prostate, pancreas, and pyloric end of the stomach. On naked-eye examination a scirrhous tumour appears as a hard nodular mass, the limits of which are imperfectly defined. When cut across, it creaks under the knife, and presents a yellowish-white surface, which rapidly becomes concave owing to the contraction of the fibrous stroma. It has often been compared to the section of an unripe pear or turnip, both on account of the grating sensation imparted to the knife and from its appearance. On scraping the cut surface with the blade of a knife, a typical cancer juice is obtained, consisting of epithelial cells and débris.

On microscopical examination, the tumour is found to consist of an abundant and well-marked stroma of a definite fibrous nature, the acini of which are filled with epithelial cells (Fig. 66). In the centre fatty degeneration is often present, small cysts being occasionally produced in this way. At the periphery the growth may be seen extending in all directions along the lymphatics, whilst a round-celled infiltration of the surrounding tissues is also evident.

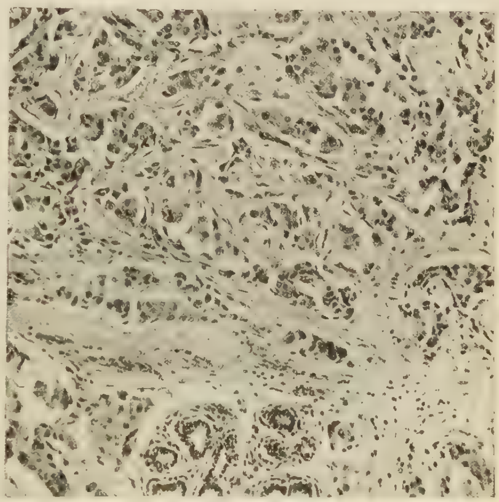

FIG. 66.—SCIRRHUS MAMMÆ (× 120.)
(A lobule of normal breast tissue is seen at the lower margin.)

Where the stroma is very excessive, the cell elements, and, indeed, the whole tumour, may undergo atrophy, owing to compression of the nutrient vessels, constituting the variety known as *atrophic scirrhus*.

Encephaloid, Medullary, or *Acute Cancer* is a term given to a growth of a similar nature, in which the stroma is much less abundant than the cell elements. It constitutes a rapidly-growing tumour, not so hard as a scirrhus, abundantly supplied with blood-vessels, and very early infiltrating surrounding parts and affecting neighbouring lymphatic glands. The skin over such a tumour is stretched, and dilated blue veins can be seen through it. Ulceration occurs early, and from this surface a foul, bleeding, fungating mass sprouts up, formerly known as a 'fungus hæmatodes' (Plate IV., Fig. 2). Encephaloid cancer is met with in the breast, testis, kidney, and a few other glandular organs.

On section it is found to be composed of a soft whitish mass, somewhat resembling brain substance. It is usually very vascular, perhaps pulsating, and hæmorrhagic extravasation into its tissues is not uncommon. An abundant juice is obtained on scraping. Under the microscope large groups of spheroidal epithelial cells are seen, held together by a scanty fibro-cellular stroma.

3. **Columnar Carcinoma.**—This affection is in the majority of cases a true glandular cancer, originating most frequently in the alimentary canal from any portion of it in which columnar epithelium occurs, and usually as an overgrowth of Lieberkühn's follicles (Fig. 67). It forms a projecting growth from the surface, and also penetrates deeply into the submucous and muscular coats. The deep processes retain an imperfect alveolar arrangement, and between them is found a certain amount of stroma, varying with the character of the tumour. In the more chronic forms the stroma is abundant, and fibro-cicatricial in quality; in the softer and more rapidly growing forms the stroma is less abundant, and fibro-cellular in nature. It is usually easy to distinguish the growth from a simple adenoma of Lieberkühn's follicles, since in the latter the alveoli are complete and regularly lined with a layer of columnar epithelium, whilst in cancer the alveoli vary in shape, and the epithelial elements are less regularly arranged. The distinction is well seen in Fig. 67. If a large section, including the whole thickness of the intestinal wall, is examined, the extension of the glandular tissue into and between the muscular fasciculi (Fig. 68) at once indicates the malignant nature of the case. Ulceration usually occurs, giving rise to a typical sore, surrounded in the more chronic

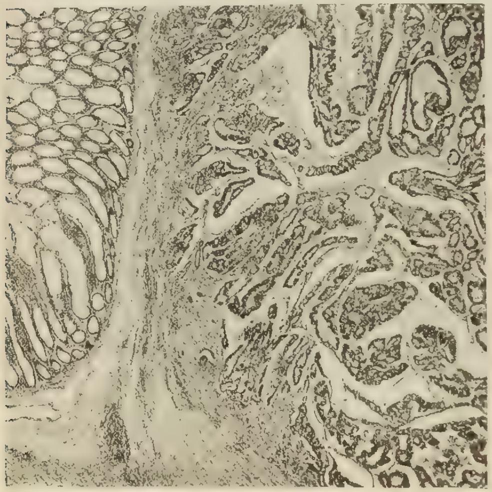

FIG. 67.—COLUMNAR-CELLED CARCINOMA OF THE INTESTINE. (× 16.)

(Normal mucous membrane is shown at the left-hand side.)

forms by indurated and everted edges. Neighbouring lymphatic glands are implicated, as in the case of all cancers, whilst later on the disease spreads to the viscera, and may be generally disseminated. A similar type of growth occurs in the cervical portion of the uterus, and occasionally in the ducts of glands, such as the liver and breast. It is also met with in the superior maxilla, originating in the tubular glands of the mucous membrane lining the antrum.

4. **Colloid Cancer** results from a degeneration of the epithelial cells of a glandular or columnar cancer. Its most frequent site is within the abdominal cavity in connection with cancers arising from the stomach, intestine, or omentum. To the naked eye it presents an alveolar texture, the spaces being filled with translucent gelatinous material of varying density. Microscopically, the epithelial cells are rarely distinguishable, being replaced by a structureless colloid substance. Towards the growing margin, however, the cells may be seen in process of degeneration, globules of the material forming within them and pressing the nucleus to one side.

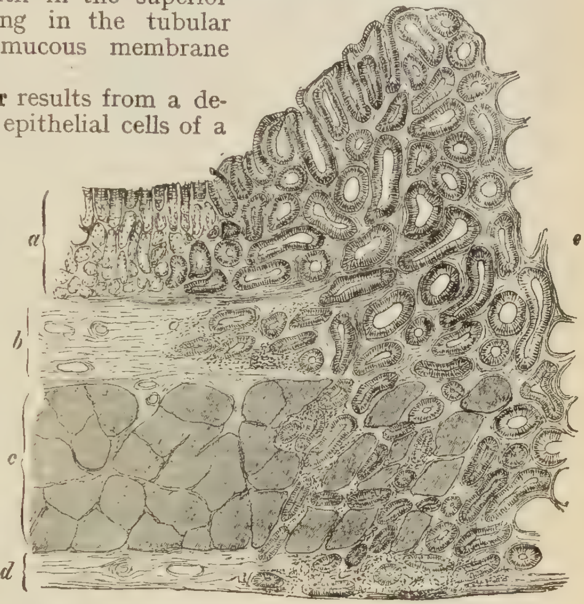

FIG. 68.—SECTION THROUGH ADVANCING MARGIN OF COLUMNAR CANCER OF STOMACH. × 25. (ZIEGLER.)

a, Mucosa; *b*, submucosa; *c*, muscularis; *d*, serosa; *e*, neoplasm which, starting from the mucosa, has invaded the other layers. Small-celled infiltration has accompanied here and there the formation of the neoplastic tubules.

The **Treatment of Cancer** has made considerable strides in recent years. Unfortunately, cases too often come under observation at such a late stage that only a small percentage of cures is possible; but the old position of hopeless and helpless expectation of a fatal issue in all cases may now be abandoned, and a cure looked for in many. The main reliance is still in operation, but experience of radio-therapy has shown that in it we have a valuable adjunct, and in suitable cases an effective alternative.

Operative treatment consists in the removal of the tumour, together with a wide margin of healthy tissue around it, or in some cases of the whole organ affected, as well as of the lymphatic area concerned, and, if practicable, in one mass, so as not to cut across the lymphatic vessels passing from the growth to the glands. The wide area of permeation by the cancer cells, and the impossibility of recognising their existence in the tissues, explains the extensive scope of such operations, and the only too frequent recurrence locally or in the course of the lymph-stream. In spite of this, however, better results are being obtained, thanks in part to our increasing knowledge of the anatomy of the lymphatics, and in part to the improvement in our surgical technique, which justifies more extensive operations. That surgeons can now report 17 to 50 per cent. of their patients operated on for cancer of the breast as alive and free from recurrence at periods varying from six to thirteen years is indeed a matter for congratulation; 237 operations for cancer of the uterus showed 38 per cent. of the patients free from recurrence after an interval of five years; of 114 cases of cancer of the lip, 53 per cent. were alive and well, or dead from some other disease, more than three years after operation (Göttingen clinique). Results such as these, which could be easily added to, prove that *cancer is curable by operation* if it be seen early enough, but it is from early diagnosis that we can alone hope for better results

The *non-operative treatment* of cancer is only required in cases where the disease is very superficial—*e.g.*, rodent ulcer, and some forms of epithelioma, or where it is impossible to remove it completely by operation.

The introduction of *radio-therapy* has placed at the surgeon's disposal an active and valuable remedy, which in suitable cases can be effective. Its method of use, value, and limitations, have been already discussed (p. 55).

Apart from such measures, there are no certain cures for cancer. Many substances have been vaunted in this direction, but careful trials under trained observers have always resulted in disappointment. In some few instances the growth of the tumour has been hindered by tying the nutrient vessels—*e.g.*, the external carotid and its branches in cancers of the head—and pain has been relieved by division of sensory nerves. In ulcerating cases, the adoption of careful aseptic methods and the use of a staphylococcic vaccine may reduce the inflammatory reaction, and cause temporary improvement. In the final stages, morphia or heroin can alone be depended upon to give some relief to the patient's pain.

In conclusion, one must point out that in a very small percentage of cases a natural cure is possible, the tumour shrinking and gradually disappearing. Unfortunately, nothing definite is known as to the conditions which favour such a happy issue.

III. Tumours of Endothelial Origin.

The **Endotheliomata** form a large and important group of tumours. They are by no means rare, and as a class are much less malignant than the sarcomata or carcinomata, to which they often have a close structural resemblance; they are slow in their development, but often recur locally after removal, and may, after a time, affect glands or form secondary deposits in internal organs. Their most frequent seat is in the parotid gland, where they form the *mixed parotid tumour* of the older surgeons, but they are common in other parts in the neighbourhood of the mouth and in the meninges of the brain and cord; they may occur, however, in any part of the body. The cells constituting an endothelioma are derived from the preexisting endothelium of the region, and they become spherical, cuboidal, or even columnar in shape, and take on independent growth. The tumour may start in the lymphatic clefts, which then appear to be injected with cuboidal cells, and form a cellular network having a general resemblance to a carcinoma. The stroma between these columns is profoundly altered, usually becoming mucoid or converted into a hyaline tissue resembling cartilage (Fig. 69); fat is often deposited in it, and cystic degeneration may take place, the tumour thus formed being of extraordinary complexity. In some cases the cells affected are those lining the smaller lymphatic vessels, and in others this may especially involve those occurring in the vascular sheaths, forming a cellular investment to the smaller vessels—*perithelioma* or *perithelial sarcoma* (Fig. 70). In a third group the endo-

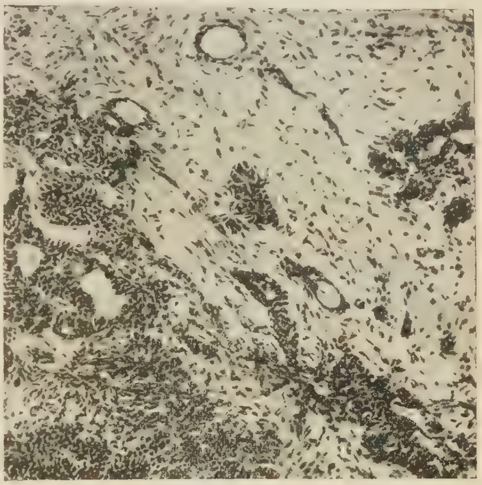
FIG. 69.—ENDOTHELIOMA OF THE PAROTID GLAND. (× 120.)

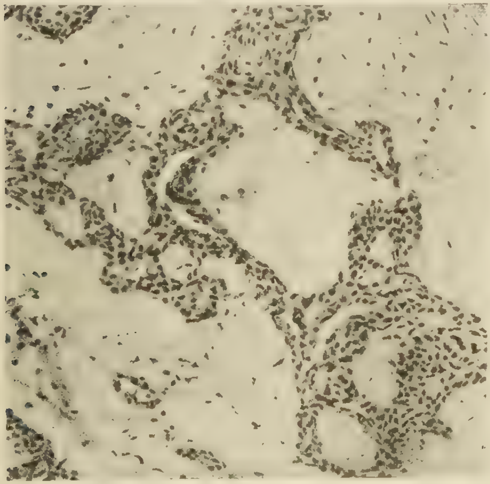
FIG. 70.—PERITHELIOMA. (× 120.)

thelium which takes on morbid growth is that which lines the blood-vessels themselves. In this case it is common for the cylinders of cells thus formed to undergo a hyaline degeneration (*cylindroma*).

The endotheliomata which occur in the brain are usually composed of spindle-shaped cells, which have a tendency to organize into fibrous tissue, and have a curious arrangement in whorls, something like those of a cell-nest. The central portions of these masses frequently undergo conversion into a material resembling amyloid substance, and subsequently become calcified. These tumours are called *Psammomata.* Endotheliomata of the brain are not uncommon, and are generally superficial, readily shelled out, and do not usually recur after operation.

IV. Tumours formed by Inclusion of Part of another Embryo.

Teratomata are tumours derived from included embryos, or from portions of a second embryo, which are formed by dichotomy, but which have remained rudimentary, and partially or completely buried in the tissues of the host. The commonest example is the so-called *dermoid of the ovary,* which is usually unilocular and often of large size. Its lining wall is more or less obviously cutaneous in nature, and from it an abundant development of cutaneous appendages—hair, nails, teeth, nipples, mammæ, etc.—is sometimes observed. Most commonly the cyst is filled with greasy sebaceous material and with an abundance of hair, which is said to be influenced in the same way as that on the scalp, becoming gray or being shed at the same time. Sometimes the tumour becomes more complex, containing structures such as bone, muscle, gland tissue, etc., which are formed from all three layers of the embryo; in some rare cases large portions of an embryo (such as a limb) are recognisable. Similar dermoids are found in the testis and in other portions of the body, though very unfrequently. Teratomata of complex structure are often found in the sacral region, where they are probably due to posterior dichotomy, the smaller portion of the embryo remaining rudimentary and attached to the larger twin in the region of the sacrum.

Cysts.

By a cyst is usually meant a more or less rounded cavity, with a distinct lining membrane, distended with some fluid or semi-solid material. The term is used very loosely, being applied to a variety of manifestations which it is difficult to classify, owing to the fact that conditions which are pathologically similar in origin are sometimes termed cysts in one part of the body, and not so in another. For practical purposes, however, they may be grouped as follows:

I. Cysts of *embryonic origin,* or arising in connection with embryonic remains.

II. Cysts arising from the *distension of pre-existing spaces* (distension cysts).

III. Cysts of *new formation.*

IV. Cysts of *degeneration.*

I. Cysts of Embryonic Origin, or arising in Connection with Embryonic Remains.

1. **Dermoids** are characterized by the existence in abnormal situations of cavities lined with epithelium, from which may be developed such cutaneous appendages as hairs and nails, whilst the space is usually occupied by sebaceous contents. The structure of the lining wall is very similar in nature to skin or mucous membrane, consisting of stratified epithelium, from which a considerable growth of sebaceous glands and hair follicles often takes place. If teeth or more complex tissues, such as bony alveoli, mammary glands, nipples, etc., develop in such a cavity, it should probably be looked on as a teratoma.

Several varieties of dermoids are described:

(*a*) **Sequestration Dermoids** are cysts arising from the incomplete disappearance of surface epithelium in situations where, during embryonic life, fleshy segments coalesce. Thus, in almost any part of the middle line of the body such tumours may develop, owing to the fact that there is here a union of two lateral segments. Similarly, they are not uncommon about the face and neck, occurring along the lines of the facial and branchial clefts. Perhaps the most common position for them in this region is the upper portion of the orbito-nasal cleft, behind, and to the outer side of the eye (Fig. 71). It is not unusual to find the skull defective beneath them, and a pedicle extending from the deep side, connecting them with the dura mater. Sequestration dermoids appear as rounded, definitely limited tumours, firm and elastic to the touch, over which the skin glides freely, but are usually somewhat adherent to the deeper parts. This form of dermoid may be removed without difficulty, but in those occurring about the scalp, with the bone hollowed out beneath them, it is perhaps advisable to delay operation till adult life, unless the tumours are rapidly increasing in size. The reason for this is that the bone gradually grows up around the pedicle, and thus closes the communication with the cranial cavity. In some cases it may be difficult to remove the whole of the lining membrane by dissection, and under these circumstances the portion left behind should be destroyed by cautery or caustics: otherwise, recurrence is almost certain to follow.

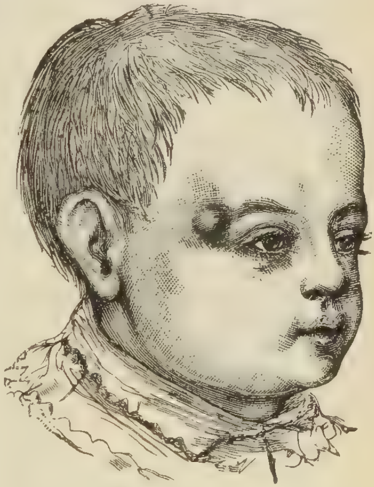
FIG. 71.—DERMOID CYST, GROWING AT THE OUTER ANGLE OF THE ORBIT (BLAND SUTTON.)

(*b*) **Tubulo-Dermoids** arise in connection with embryonic canals and passages, such as the thyro-glossal duct and the post-anal gut (*q.v.*).

(*c*) For **Ovarian Dermoids,** see p. 228.

2. **Cysts** occasionally arise *in connection with* the formation of *the teeth;* such have been already alluded to under the terms follicular and epithelial odontomes (p. 215), the former being also known as dentigerous cysts, the latter as fibro-cystic disease of the jaw.

3. Various cysts develop in connection with *the remains of the Wolffian body,* as also from *its tubules and duct.* It must be remembered that this body (the *mesonephros*) arises in the posterior abdominal wall, together with the kidney and testis, and that part of it enters into the formation of the latter; hence one is not surprised to find that its remains are closely associated with that organ in the scrotum.

In the **male** (Fig. 72) the Wolffian body atrophies almost completely, being represented by a few blind tubules, situated close to the epididymis, and known as the paradidymis, or organ of Giraldés. Fibro-cystic disease of the testis (*adenoma testis*) is said to arise from this structure. The majority of the ducts of the Wolffian body form the vasa efferentia testis; a few of the upper ones, however, contract no attachment to the gland, and their free ends (known as Kobelt's tubes) may become dilated, and form small cysts, situated close to the *hydatid of Morgagni,* which structure represents the remains of the Müllerian body and duct. It is possible that an *encysted hydrocele of the epididymis* sometimes arises from one of these unobliterated tubules. The main duct of the Wolffian body forms the lower portions of the epididymis and vas deferens.

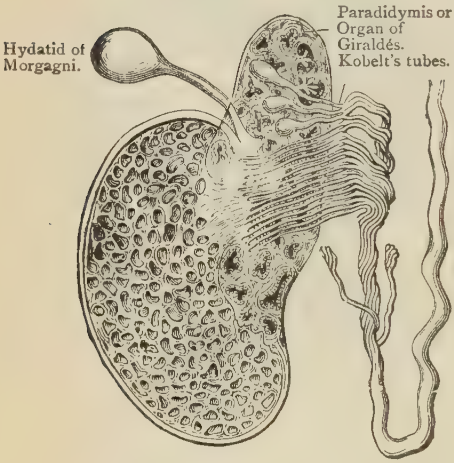

Fig. 72.—Diagram of Adult Testicle, to show Relation of Mesonephros and its Ducts. (Bland Sutton.)

In the **female** (Fig. 73) the remains of the Wolffian body are sometimes met with as a series of closed tubes (paroöphoron) in the neighbourhood of the ovary. *Paroöphoritic Cysts* may arise in connection with this structure, and are chiefly characterized by their inner walls being the seat of proliferating papillomata. The Wolffian tubules can almost always be recognised in the broad ligament, constituting the parovarium, or organ of Rosenmüller. *Parovarian Cysts* formed from the distension of this structure are usually unilocular, and filled with a clear limpid serous fluid; they have no definite pedicle, and strip up the layers of the broad ligament. Some of the terminal tubes may be converted into small cysts which project from the fimbriated ends of the Fallopian tube, and are known as *cysts of Kobelt's tubes.* The main Wolffian duct generally atrophies, but occasionally runs down between the layers of the broad ligament close to the uterus, to open in the vagina near the urethral orifice, being then known as Gärtner's duct. Cysts may occasionally arise in connection with this structure, projecting into the lateral fornix of the vagina.

4. The *processus vaginalis,* or funicular process, is the term applied to the protrusion of peritoneum which precedes the testis to form the tunica vaginalis, and which in the female accompanies the round ligament (*canal of Nuck*). Normally it becomes obliterated, but sometimes portions remain patent, and are distended with a clear straw-coloured serous fluid, constituting in the male an *encysted hydrocele of the cord,* and in the female a *hydrocele of the round ligament.*

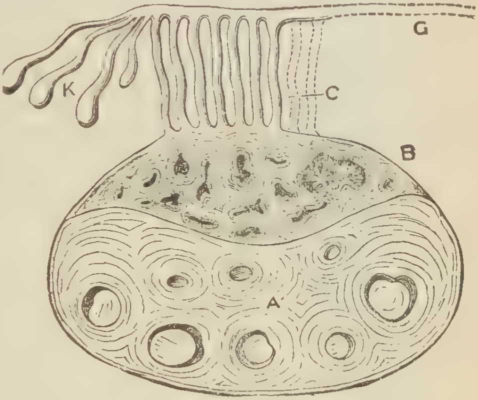

Fig. 73.—Diagram to represent the Cyst Regions of the Ovary. (Bland Sutton.)

A, Oöphoron, or ovarian tissue; B, paroöphoron, or tissue of the hilus; C, parovarium; K, Kobelt's tubes; G, Gärtner's duct (=main Wolffian duct).

5. Cysts arise occasionally in connection with some irregular development of the lymphatic spaces; thus, in the neck the so-called *cystic hygroma* is in reality a congenital cavernous lymphangiectasis.

II. Cysts due to the Distension of Pre-existing Spaces.

(*a*) **Exudation Cysts** arise from the distension of cavities which are unprovided with excretory ducts, and are frequently of inflammatory origin. Such spaces may be lined with epithelium or endothelium. As illustrations of *epithelial* cysts may be mentioned those which arise in connection with the thyroid body, as also conditions due to the distension of the central canal of the nervous system (syringomyelocele), and those forms of ovarian cyst which arise from distension of Graafian follicles.

Exudation cysts lined by an *endothelial* wall are much more numerous. Enlargements of bursæ, hydroceles of the tunica vaginalis or funicular process, and some forms of ganglia, are of this nature. Diverticula or hernial protrusions of the synovial membrane of joints are known as Baker's cysts.

A *Serous Cyst* is supposed to arise from the distension of lymph spaces, giving rise to uni- or multi-locular cavities, lined with endothelium, and containing a limpid straw-coloured fluid. They are seen most commonly in the neck, axilla, or breast, and in the latter structure may be surrounded by dense fibrous tissue. They may be looked on as cavernous lymphangiomata.

Adventitious Bursæ arise as a result of repeated irritation, and are dealt with elsewhere.

(*b*) When a collection of blood forms in a pre-existing cavity, a so-called **Cyst of Extravasation** is produced. Such is met with in the pelvis or tunica vaginalis (hæmatocele), and also occasionally on the surface of the brain, constituting an arachnoid cyst.

(*c*) **Retention Cysts** always arise from obstruction to the escape of some natural secretion from a gland duct or tubule. The cavity thus formed is lined with epithelium, whilst, owing to the irritation produced by the tension, a fibro-cicatricial wall of variable thickness is developed outside. There is sometimes a considerable formation of intracystic growths, especially in the breast, whilst the contents generally consist of the inspissated secretion, perhaps mixed with blood.

Retention cysts may develop in connection with any glandular tissue. The majority are described under the appropriate headings —viz., mammary cysts, renal cysts, pancreatic cysts, etc.

III. **Cysts of New Formation** are such as occur apart from any embryonic condition or pre-existing cavity. The following varieties may be described:

(*a*) An **Implantation Cyst** is one which arises from the accidental intrusion into the subcutaneous or submucous tissues of epithelial cells which retain their vitality, and are enabled to develop a cyst very similar in nature to a dermoid; in fact, it may be looked upon as an *Acquired* or *Traumatic Dermoid*. Such an occurrence is usually brought about as the result of an injury, especially from punctured wounds; thus, cysts of this nature have been met with in the fingers or palm of the hand as a consequence of the penetration of some sharp instrument, whilst they are also occasionally seen in the anterior chamber of the eye, following an iridectomy. They are, moreover, observed in the axillæ of cattle, as a result of goading them with a sharp implement. The clinical signs and treatment are similar to those of a dermoid cyst.

(*b*) **Cysts** may form **around foreign bodies,** which thus become encapsuled. They are lined with granulation tissue or endothelium, surrounded by a variable amount of fibro-cicatricial tissue.

(*c*) **Blood Cysts** are of variable origin. Some certainly arise from extravasation of blood, and are then filled with coagulated blood, or a thin serous fluid with a varying amount of laminated fibrin.

In many cases a so-called blood cyst is really a soft sarcoma, into which hæmorrhage has occurred; but a few instances are on record in which a thin-walled cavity existed, occupied by blood, and readily refilling after it had been tapped, and with no evidence of any growth. Such conditions have been most frequently observed in the neck (see Chapter XXXII.).

(*d*) **Parasitic Cysts** are produced by the irritation caused by the growth within the tissues of certain living organisms. Thus, in the disease known as trichinosis, derived from eating unsound pork, the *Trichina spiralis*, a small round worm, develops in large numbers in the voluntary muscles, and becomes surrounded by a capsule which is subsequently calcified.

The most important of these parasitic cysts is that caused by the development within the body of the scolex stage of the *Tænia echinococcus*, giving rise to what are known as **Hydatid Cysts.** This disease is much more common in Australia than in this country. The *Tænia echinococcus* (Fig. 74) is a minute tapeworm, less than half an inch in length, which inhabits the intestinal canal of dogs; it consists of four segments, the posterior one being larger than the rest of the body, and containing the genital organs. When mature, this last segment becomes filled with ova, which are discharged, and these find their way into the human stomach by the media of water or uncooked vegetables, such as watercress, which have been contaminated with the dog's excreta. The process of digestion sets the embryo free, and by means of a crown of little hooks which it possesses, as well as four suckers, it is enabled to bore its way through the walls of the stomach, and thence travels by the bloodvessels to the liver or some other part of the body. As a result of the irritation caused by its presence, a sac forms, which originally consists of three layers (Fig. 75); externally, a fibro-cicatricial layer, then an intermediate lamellated layer of chitinous material (true *ectocyst*), and finally the cyst is lined by a protoplasmic germinal layer (*endocyst*), from which may be developed solitary tænia heads or scolices, also provided with four suckers and a circlet of hooks, whilst sometimes groups of them, known as brood-capsules, may arise in the same way (Fig. 76). Daughter-cysts are not unfrequently formed from the scolices, and they in their turn may pass through the same changes, although as a rule they are barren. Occasionally even the main cyst may be sterile (*acephalocyst*), and in such cases the walls become very definitely laminated. The fluid contained in the cyst varies much in amount, but is always

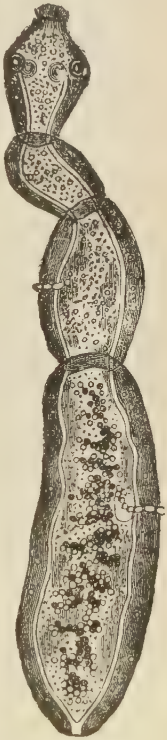

FIG. 74.—TÆNIA ECHINOCOCCUS. (× ABOUT 20.)

of low specific gravity, not more than 1007; it is colourless, but slightly opalescent, limpid, and contains but a trace of albumen, although a considerable amount of chloride of sodium is present.

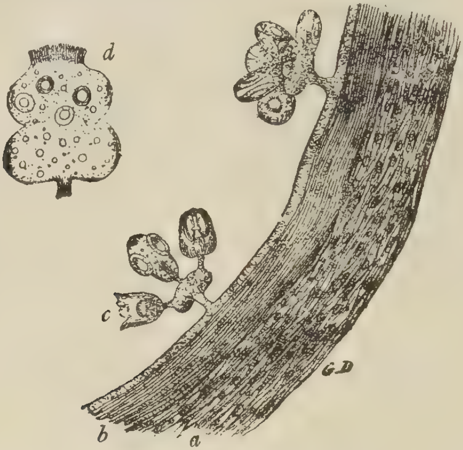

FIG. 75.—DIAGRAMMATIC SECTION OF WALL OF CYST.

a, Fibro-cellular capsule, here somewhat exaggerated; *b*, lamellated chitinous layer, or ectocyst; *c*, brood-capsules developing from the protoplasmic layer, or endocyst; *d*, scolex, or separate head, enlarged

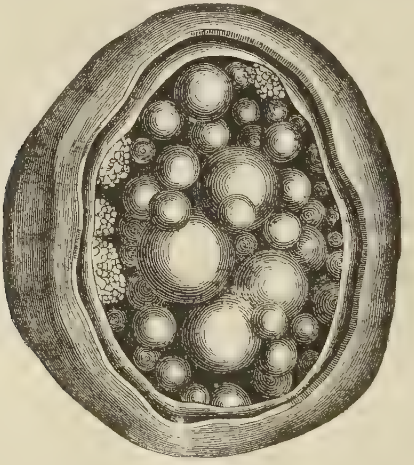

FIG. 76.—HYDATID CYST (DIAGRAMMATIC), SHOWING DAUGHTER-CYSTS AND BROOD-CAPSULES GROWING FROM THE WALLS. (AFTER BLAND SUTTON.)

On examining the fluid microscopically, the characteristic hooklets are observed. The organs usually affected by hydatid disease are the liver, kidneys, and brain, but any part of the body may be attacked. Occasionally in the liver, and usually in bone, multiple cysts develop quite distinct from each other, and with no general cyst-wall (*exogenous* multiplication). This can only occur when the ectocyst is thin, allowing the scolices, which always have a retractile neck, to push through and ' swarm off ' into surrounding tissues.

Hydatid cysts give rise to no special symptoms, except those caused by their size and situation, and they are likely to go on growing until operative treatment becomes imperative on account of some complication, or from the size of the mass. At any time the cyst may *rupture*, either spontaneously or as the result of some injury; if into a serous cavity, such as the peritoneal or pleural, this becomes infected, and an abundant development of scolices and cysts ensues, giving rise to considerable localized inflammatory reaction; moreover, the escape of the cyst fluid may cause serious toxæmia, or, at any rate, urticaria, owing to the presence therein of some toxic substance.

Occasionally the organism *dies spontaneously*, and then the cyst shrivels up, and the laminated walls and daughter-cysts form a firm leathery mass, perhaps infiltrated with lime salts and of the consistency of wet mortar; a thick fibro-cicatricial capsule encloses the whole. At other times *suppuration* takes place within the cyst, and an abscess results. If acute, it bursts either externally, or may open into some serous cavity or hollow viscus; in the last case, the cyst may evacuate itself, and a spontaneous cure result. Sometimes the abscess becomes chronic and encapsuled, and may then remain quiescent for years.

For the diagnosis and treatment of hydatid cyst of the *liver*, see Chapter XXXV. In other regions, if the tumour cannot be removed by dissection, reliance must be placed on drainage, where the situation of the growth renders this practicable, or aspiration, since it is usually found that removal of the fluid contents causes death of the organism, probably by altering the intracystic tension.

IV. **Cysts of Degeneration** arise in connection with tumours, especially those where the blood-supply is not very abundant. Thus, mucoid degeneration is not uncommon in fibromata, fibro-myomata, chondromata, and even in the harder forms of cancer. Occasionally cysts form in the sarcomata from this cause, but more frequently as a result of hæmorrhage.

CHAPTER X.

WOUNDS.

A WOUND has been defined as the forcible solution of continuity of any of the tissues of the body; but the term is more commonly limited to injuries of the soft parts, involving the skin or mucous membranes. Lesions in which the skin does not participate, and in which the deeper structures, such as bones, ligaments, etc., are not involved, are spoken of as contusions.

A **Contusion** is any subcutaneous wound or injury due to the agency of external violence, causing laceration of the cellular tissue, without necessarily involving such deeper structures as muscles, tendons, nerves, or bones. The signs are usually very obvious, viz., **pain, bruising,** or discoloration of the part, and **swelling.** These are readily explained by the injury inflicted on the subcutaneous tissues, which in the worst cases may be entirely disorganized and separated from the skin. The amount of bruising varies with the part injured and the severity of the lesion; thus, in the eyelids, scrotum, and vulva, where the tissues are lax, the ecchymosis will be very extensive and of a black colour; on the scalp there is, on the other hand, but little swelling, if the injury does not include bleeding beneath the aponeurosis of the occipito-frontalis. Again, the condition of the patient's general health influences the amount of blood effused; a strong man in good training does not bruise nearly as much as those of a languid temperament and relaxed tissues. Blebs and bullæ may form over the injured spot, especially in connection with fractures. The changes that occur in a bruise are well known, the colour passing from a blackish-purple through various shades of brown and green to a yellow, which gradually fades and disappears; this is due to the disintegration of the red corpuscles, and staining of the tissues by the hæmoglobin thus set free, or by the products formed during its removal. When hæmorrhage has taken place into the deeper parts or under dense fasciæ, it is often some days before the bruise 'comes out,' and this may occur at some distant spot, *e.g.*, in the eyelids after a blow on the scalp, whilst it may travel along the muscular and fascial planes under the influence of gravity.

In a bruise or ecchymosis, the tissues are, as a rule, merely infiltrated with blood, but occasionally the extravasation is more localized, collecting in a cavity formed by the laceration of the tissues, and remaining as a fluid swelling, or **Hæmatoma.** It somewhat resembles an abscess to the touch, but differs from it in its history, having supervened immediately after an injury, and having appeared without any heat or other sign of inflammation; moreover, though at first fluid and soft, it soon becomes harder, whereas an abscess is preceded by a stage of brawny infiltration, and the softening occurs later. The subsequent history of a hæmatoma varies somewhat according to circumstances. (*a*) Fibrin may be deposited peripherally, leaving for a time a fluid centre, which gradually disappears, and the whole is finally absorbed. This is well exemplified in a subpericranial cephalhæmatoma, where the contrast between the peripheral fibrinous deposit and the fluid centre, through which the skull can be felt, is sometimes so accentuated as to give the sensation of a depressed fracture. (*b*) The fluid portion of the blood may be absorbed almost entirely, and the solid fibrinous residuum may become organized into a firm fibroid tumour which persists indefinitely; the mass is more or less laminated, and not unfrequently pigmented. (*c*) The fibrin may be entirely absorbed, and a slightly pigmented fibrous capsule formed containing serous fluid, and constituting a definite cyst; this is best seen in connection with the cerebral tunics (*arachnoid cyst*). (*d*) Suppuration may ensue owing to auto-infection from within the body, or from an invasion of organisms through abraded skin.

In forming an opinion as to the gravity of a subcutaneous injury, one must be guided by the character and extent of tissue involved. the amount of blood extravasated, and the age and vitality of the individual. In the less severe cases, though there may be much bruising, recovery will ensue, but in unfavourable conditions sloughing and death of the injured tissues may result.

The **Treatment** of a bruise usually consists in keeping the part at rest, and applying cold or evaporating lotions. The effusion of blood may be hindered, if the case is seen early, by firm bandaging of the part over a compress of cotton-wool. In the later stages absorption of the blood may be hastened by massage. In the severer cases, where blebs or bullæ have formed or there is a likelihood of the skin sloughing, it must be carefully washed and rendered aseptic, and, if need be, wrapped in an aseptic dressing. When a tense and painful hæmatoma exists, as under the fascia lata of the thigh, recovery can be hastened and pain relieved by an aseptic puncture, followed by careful compression. In general bruising of the body from a fall or extensive injury, pain can often be relieved by applying fomentations or by a hot bath. There is usually a certain amount of fever and constitutional disturbance for a few days, and these are dealt with by purgatives and a suitable limitation of diet.

Open Wounds.

An open wound may be defined as a solution of continuity of any superficial part of the body, including skin or mucous membrane. Various kinds of wounds are described, such as the incised, lacerated, contused, punctured, poisoned, and gunshot; but, of course, the most important distinction to draw is between the infected and the non-infected.

I. **Incised Wounds.**—An incised wound is one made by any sharp cutting instrument, but occasionally one not produced in this manner may be characterized by similar appearances; *e.g.*, the skin of the knee or elbow may be cleanly split open from falling on it with the limb flexed, and occasionally a policeman's truncheon will lay open the scalp almost as evenly as if a knife had been employed.

The special features of an incised wound are as follows:

1. The hæmorrhage is free, from the fact that the vessels are cleanly divided. The amount necessarily depends on the size of the vessels involved, and the vascularity of the part; its continuance, upon the density of the structures allowing or not of contraction and retraction of the severed ends.

2. Separation of the lips of the wound also occurs, the amount depending upon the elasticity and character of the part involved and the degree of tension to which it is exposed.

3. Bruising of the margins of the incision is absent, so that under ordinary circumstances rapid healing (by first intention) should obtain. The surfaces, to begin with, are lined by a microscopic layer of damaged tissue, some of which may be actually dead; but if suitable precautions are taken, this is absorbed, and in no way interferes with satisfactory union.

The chief dangers of an incised wound are: (1) Hæmorrhage; (2) injury to subcutaneous structures, such as nerves, tendons, muscles, etc.; and (3) the risks involved from infection.

Treatment of Incised Wounds.—Seven essentials must be attended tc if healing by first intention is to be obtained, viz. :

(i.) **The Arrest of all Bleeding.**—General oozing may be stayed by exposure to the air or the pressure of an aseptic swab. Arteries and veins will need a ligature, but if situated close to the skin, they may sometimes be secured by passing under the bleeding spot the needle used for the suture. The importance of complete hæmostasis in limiting or hindering bacterial developments has been already alluded to (p. 4).

(ii.) **Sterilization of the Wound and its Surroundings.**—In casualty work asepsis cannot be always assured, as the wound, though cleanly cut, is made through dirty skin, and portions of clothing, dirt, and splinters of wood or glass may be carried in. Under these circumstances the wound and its surroundings must be thoroughly purified, according to the rules given on p. 278, and a careful search made for foreign bodies.

(iii.) **The coaptation of the opposed surfaces** by means of **sutures** may now be undertaken. Many substances are employed for this purpose, but amongst the best are fine silver wire, silk, horsehair, silkworm gut and catgut. In casualty work, and for parts of the body where but little scar is subsequently desirable, as in the face, horsehair and silkworm gut, being non-absorbent, are perhaps the best materials to employ; but in ordinary operative work, which will be more certainly aseptic, and where the after-treatment is more efficient, fine catgut or silk may be used. There are three chief varieties of sutures, viz., the buried, the deep, and the superficial.

Buried sutures are now largely employed, since a foreign body may be safely inserted into the tissues, if both it and the wound are aseptic. Some discrimination must be employed in the selection of the material chosen for a buried stitch, according to whether or not it is desirable that it should persist or be absorbed. If a part is not very strong and the cicatrix is exposed to a certain amount of tension, as in the abdominal wall after a laparotomy, non-absorbent material such as silk or silkworm-gut may be employed, and the incorporation of the suture in the cicatrix will prove a source of strength. At the same time it must be remembered that, if drawn too tight, the tissues within its grasp may be strangled, and suppuration at a later date determined even apart from external infection. In other cases all that is required of a buried stitch is to hold certain tissues in contact until a natural bond of union has developed, and then the sooner the stitch disappears the better—*e.g.*, in building up the tissues of the neck after the removal of a goitre or in re-uniting a divided nerve; for such a purpose fine catgut slightly chromicized answers admirably.

Deep stitches, or *sutures of relaxation*, are required in cases where there is difficulty in bringing the edges of the wound together, in order to transfer the tension from the healing margin to tissues further away, the edges being thereby relaxed. For this purpose thick silk or catgut may be employed, inserted 1 or 1½ inches from the margins, or silver wire may be used, lead buttons being interposed next to the skin, and the ends of the wire fastened round the projecting edges. Deep stitches are generally removed at the end of two or three days.

Superficial stitches, or *sutures of coaptation*, must be so inserted as to bring the edges of the wound into contact without undue pressure, and without any folding in of the skin. Various methods are employed, viz.: 1. The *interrupted suture* (Fig. 77, A), in which each stitch is separately finished off, the knot lying well to one side of the incision. This is generally utilized for wounds which are of irregular shape or in which there is tension. 2. The continuous *glover's stitch* (Fig. 77, B) is not to be recommended. 3. The *blanket* or *buttonhole stitch* (Fig. 77, C) is the form of continuous suture which should be employed for extensive wounds or incisions. In it the needle, after traversing the lips of the wound, is carried under the slack of the thread, so that the loop of each stitch, as it is tightened, is maintained at right angles to the edge of the wound, whilst the intermediate portion lies parallel to it. 4. Halstead's *intradermic* or *subcuticular stitch* (Fig. 77, D) may be employed when very exact coaptation is desirable, and a minimum of visible scar required, as in the face or neck. The deeper tissues must first be carefully built up by a series of buried sutures, so that the margins of the wound are nearly in apposition. Fine silkworm-gut or silver wire is employed, and a short straight needle. The needle is introduced in the substance of the skin beneath the cuticle and passed parallel with the surface, to emerge on the same level less than a centimetre from the point of introduction, thereby taking up a semicircle of tissue; it is then introduced in a similar way on the opposite side of the incision, and the process is repeated from one end of the wound to the other. The suture is finally pulled tight at each end, and left long. To remove it, one end is cut short, and then a steady pull on the other end draws out the remainder quickly and without pain. 5. Metallic clips (*e.g.*, Michel's) are used by some surgeons instead of sutures, but they have no real advantage.

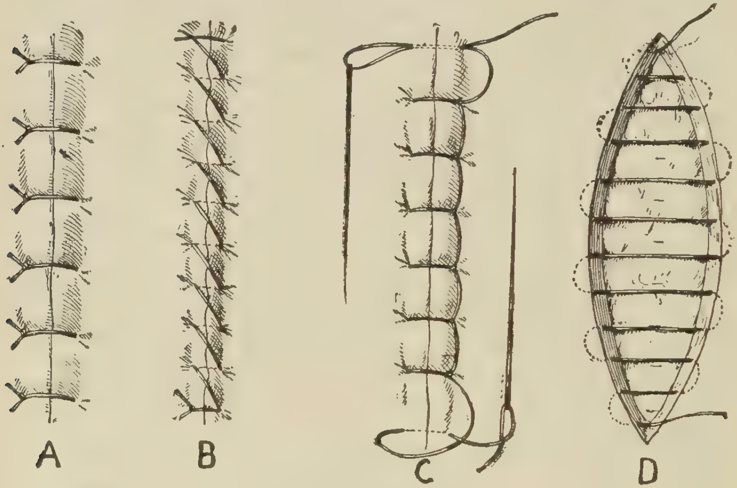

FIG. 77.—VARIOUS FORMS OF SUTURE.

A, Interrupted suture; B, continuous suture; C, blanket stitch. At the lower end the needle has just been passed, and the way in which it catches up the loop is indicated. At the upper end the method of finishing off (originally suggested by the late Mr. Maunsell) is shown; viz., the needle is passed in the opposite direction to all the other stitches, the free end being left long, so as to enable it to be tied into a knot with the double thread which the needle has carried through; D, Halstead's intradermic or subcuticular stitch.

Adhesive plaster is sometimes employed, but the wounds must be very small and insignificant which only require such treatment. A fine aseptic suture is in most cases preferable.

(iv.) **Drainage** must, if necessary, be provided, in order to guard against the irritation and tension caused by retained blood or exudations. In casualty wounds, where there is doubt as to the completeness of the asepsis or hæmostasis, or where there has been much tearing or laceration of tissues, it is often wise to insert a tube for twenty-four or forty-eight hours.

When drainage is required, the indiarubber tube introduced by Chassaignac answers well; the end should be cut flush with the surface, and stitched to the edges of the wound, so as to prevent it slipping in or out. For small wounds, a strand of horsehair or a strip of gauze or protective will usually suffice.

(v.) **All fresh sources of irritation and infection** of the wound must be excluded by some form of antiseptic or aseptic dressing.

(vi.) **Rest** to the injured part must be secured by such an arrangement of splints, slings, or bandages as may be necessary.

(vii.) The **general health** of the patient is a most important item to attend to. In an operation case the bowels should, if possible, be previously opened, and the patient's diet carefully regulated; in casualty work a good purge should be administered as soon as convenient, and the food and drink limited.

Under ordinary circumstances an aseptic incised wound heals in about five to seven days, but the actual time when it is safe to remove the stitches varies with the age and vigour of the individual, the part of the body, and the amount of tension required to draw the lips of the wound together. In ordinary aseptic operation wounds one usually removes the stitches on the eighth day; but in the face it is often possible and advisable to take them out earlier, partly because the healing process is quickly accomplished in such a vascular region, partly in order to minimize the amount of scarring.

Many conditions may arise to *prevent* the healing of an incised wound by first intention, and they may be epitomized as essentially the reverse of the seven conditions mentioned above—viz., (i.) Non-arrest of the bleeding, causing separation of the lips or deeper portions of the wound; (ii.) the presence of impure foreign bodies or failure of the antiseptic precautions; (iii.) the edges not being brought into contact; (iv.) imperfect drainage, leading to tension on the stitches; (v.) late infection of the wound from various causes; (vi.) lack of rest to the part; and (vii.) constitutional conditions, such as deficient general vitality from disease or other causes.

When blood collects in the deeper parts of the wound, the skin incision may heal satisfactorily, but there may be some local tenderness, and a little swelling, and some slight fever, the temperature running up at night to about 100°. In such cases it usually suffices partially to open the incision, squeeze or press out the fluid, and insert a small tube or gauze drain. (For Wound Infection, see p. 90.)

II. **Lacerated or Contused Wounds.**—Such injuries are caused by blunt instruments, by machinery, missiles, the wheels of a vehicle, etc. They are characterized by the following signs:

1. The hæmorrhage is, as a rule, but slight, since the vessels are torn across irregularly, and not cut cleanly; the middle and inner coats, which give way first, are curled up within the contorted outer coat, forming a barrier sufficient to prevent loss of blood. The vessels, being elastic, may be pulled out of their sheaths, and are sometimes seen pulsating upon the surface.

2. The amount of damage inflicted varies with the character of the injury, but is often so considerable as to involve the death, at once or subsequently, of considerable portions of tissue. The skin is irregularly torn, and may be extensively stripped from underlying parts; muscles and tendons may be laid bare, or torn from their attachments; nerves may be lacerated; bones crushed and comminuted; joints laid open; and all these damaged tissues may be hopelessly infected by the dust and dirt which accumulates on greasy machinery, or on the roadway. Some of the injuries inflicted by heavy motor vehicles are horribly severe. When a limb is torn completely off, the tendons are often left long, and the muscular bellies project from their fascial sheaths as flabby congested masses, since the skin gives way at a higher point than the subjacent structures.

The **Progress** of the case depends largely upon the question whether or not the wound can be rendered aseptic.

In an **Aseptic** lacerated wound it may be possible to bring the edges together by suture or otherwise, and, even though they are a little bruised, healing by a slightly delayed first intention is possible if drainage is provided. When the wound remains open, the dead tissue is absorbed or separated, and an aseptic granulating surface results. There may be some simple traumatic fever for a day or two, but it is of little consequence.

If the wound is **Infected,** however, inflammatory phenomena supervene, as a result of which bruised and dead tissues have to be absorbed or cast off by a process of suppuration, which finally leaves a granulating surface. Three stages may be described in the course of the case, viz.:

(*a*) The stage of injury, resulting in shock, which may be very severe if large nerve trunks have been crushed.

(*b*) The stage of inflammation and sloughing, which lasts a week, ten days, or more, according to circumstances, and during this period the patient is liable to various forms of infective trouble, including secondary hæmorrhage, toxæmia, pyæmia, tetanus, and traumatic gangrene.

(*c*) The stage of repair by granulation, or prolonged suppuration, with exhaustion and hectic fever in the worst cases.

The results of the healing of injuries such as these may be quite satisfactory, or considerable trouble may be experienced at a later date from the implication of nerves in the cicatrix, or their paralysis; from the adhesions or cicatricial contraction of muscles and tendons, impairing the free mobility of the part; or from the deformity caused by the contraction of the scar.

The **Treatment** of contused and lacerated wounds varies with their character, and no absolute rule of practice can be laid down to suit all cases. The following routine is that usually adopted:

(*a*) **Immediate Treatment.**—The great desideratum in all these cases is to render the wound aseptic. To accomplish this in severe injuries, it is wise to anæsthetize the patient, and then, after shaving and purifying the skin, the wound is thoroughly irrigated with some effective antiseptic, such as carbolic lotion (1 in 20), or with salt solution and peroxide of hydrogen. Foreign bodies are removed, and dead or doubtful tissues cut away, if unimportant, whilst bleeding vessels are secured by ligature; it may be advisable to enlarge the wound in order to deal effectively with it. Ample provision must be made for drainage, since the antiseptic irrigation of itself causes much exudation; occasionally it is desirable to make a counter-opening for this purpose. Ragged or torn fragments of skin are removed by knife or scissors, and then, if sufficient tissue remains, the wound may be loosely closed by a few interrupted sutures, and an antiseptic dressing of the usual type applied. If, however, the skin is scanty and asepsis not assured, it is better to leave the wound open, or, at any rate, only to close it partially, packing it carefully with gauze impregnated with iodoform. One cannot lay too much stress upon the *danger of accurately suturing up badly lacerated wounds where asepsis is not assured.*

(*b*) **Subsequent Treatment** depends on whether or not the measures adopted to obtain asepsis have been successful. If the wound remains free from infection, nothing special is required. If infection occurs, cellulitis, associated with a certain degree of sloughing, will follow, and necessitate opening the wound freely, and following up any burrowing suppuration by free incisions. Fomentations, baths, etc., will be required as long as the inflammatory process lasts. When the suppuration has ceased and the sloughs have separated, healing by granulation will occur. It must be remembered that secondary hæmorrhage may occur when the dead tissues are finally detached. During this period inflammatory fever continues, and the patient's general health must be closely watched. When once a clean granulating surface is obtained, it is treated in the same way as any healing wound, skin-grafting possibly being needed in the more extensive cases.

The question of **Amputation** will necessarily arise in dealing with the graver forms of lacerated wounds, although many limbs are now saved which would inevitably in former days have been sacrificed. Hard-and-fast rules cannot be laid down as to when to amputate and when not to do so; each case must be treated on its own merits. The following **general** points must first be carefully considered: (*a*) The *age* and *vitality* of the patient. An old person has less recuperative power than a young one, and hence a damaged limb may often be left in a youth which one would certainly remove in an elderly person. The vitality of the individual is perhaps even more important than the age, for some men at sixty are in a much more healthy and resistant state than others at forty. The habits, as to temperance, etc., must also be taken into consideration, and the existence of general diseases, such as diabetes or albuminuria, might induce one to resort to radical rather than conservative measures. (*b*) The vitality of the *extremity* injured. A leg has to be sacrificed more frequently than an arm, since the vitality and reparative power of the latter are so much greater. (*c*) The presence or not of *infection* is of the greatest significance, since, if infection can be prevented, the chances of preserving the limb are greatly improved.

The **local** conditions which suggest or determine the performance of an amputation, may be conveniently divided into two groups—viz., where amputation is essential, or where it is doubtful.

A. **Amputation** is certainly **called for**—

1. To trim up the stump of a limb torn off by machinery, or cut off by a railway train, or blown off in an explosion.

2. When the whole limb or one complete segment of it has been totally disorganized, or crushed to pulp, though still retaining its connection with the body.

3. In cases where gangrene is imminent or has supervened, especially if it is of the spreading type.

4. When severe infective symptoms develop in a case where an attempt is being made to save a limb, the retention of which was from the first doubtful; or when exhaustion supervenes from prolonged suppuration.

5. In severe compound lacerations of the foot *in old people*, involving the bones and laying open the common synovial cavity. Infection is likely to result in disease of the bones and joints, whilst the distance of the foot from the centre of the circulation increases the likelihood of gangrene.

B. **Amputation** is **doubtful** in the following conditions:

1. Compound comminuted fractures in parts other than the foot do not *per se* require amputation unless very extensive. By careful attention to antisepsis, free drainage, and the removal of detached fragments of bone and foreign bodies, which should usually be accomplished under an anæsthetic, limbs which would have formerly been condemned to amputation can not only be preserved, but also restored to a considerable degree of functional usefulness. The final decision will largely depend on the age, condition, and previous habits of the individual.

2. When the soft parts have borne the brunt of the injury, and have been extensively stripped from the bones—*e.g.*, when the muscles of the forearm have been torn up in a machine accident—amputation is by no means an essential, provided that they can be restored to their original position, that there is a reasonable probability of their vitality being maintained, and that the utility of the limb will not be hopelessly impaired, as a result of lesions to the

nerves, after the wound has healed. The surgeon has here to balance carefully the risk run if an attempt is made to save the limb, and the value that the limb if saved will subsequently be to the patient.

3. Laceration of the main artery of a limb need not in itself determine amputation; but if in addition to this the bones, veins, or nerves are hopelessly injured, and especially in the lower extremities of old people, amputation should be undertaken without delay. In this connection it may be pointed out that in all probability tissue-grafting will be more extensively used in the future than it has been hitherto, and that already some astonishing results of this process have been attained.

III. **Punctured Wounds and Stabs.**—These may be brought about by any form of penetrating instrument, from a pin or needle to a sword, bayonet, or pickaxe. The external opening may be in itself insignificant, the chief danger arising from the damage to deep structures—bloodvessels or nerves being divided, and serous cavities or viscera opened, or even the skull penetrated. The subsequent symptoms depend almost entirely upon the question of infection; there is always considerable difficulty in draining effectively the depths of a long and narrow wound, and therefore collections of pus readily form and may burrow in all directions.

Wounds resulting from the modern **sword-bayonet,** though very serious from their size and depth, are not so difficult to heal as those inflicted by the old triangular blade. They should be effectively purified, well drained, and the skin opening not allowed to close until all discharge has ceased; if necessary, a counter-opening is made at a dependent spot. Serious hæmorrhage or paralysis calls for immediate opening up of the wound, so as to expose and deal with injured vessels or nerves.

Needles are frequently broken off short in the body, especially in the hands, feet, knees, or nates. If seen soon after the injury, it is advisable to undertake their immediate removal, a proceeding sometimes very simple, but occasionally necessitating a deep and difficult dissection. Should the needle not be removed, it may travel about the body along the muscular and fascial planes, and there is no knowing where it may lodge or come to the surface, or how long it may remain in the body; it has been known to constitute the nucleus of a renal calculus.

One of the most troublesome and painful forms of penetrating wound is that caused by a **fish-hook,** since the barbed end catches in the tissues, and it is impossible to withdraw it without increasing the size of the wound considerably. The simplest plan of treatment is to push on the hook and make it protrude through the skin elsewhere to such an extent as to enable the barb to be cut away, when the remainder of the hook will be set free.

For the detection of penetrating foreign bodies of a metallic nature, or of splinters of glass or stone, the X rays are exceedingly valuable (Figs. 78, 79), but one need scarcely point out that such plates are useless as means of localizing the foreign body; thus one could not even say on which side of the bones (dorsal or palmar) the substance is located. It is, therefore, always necessary to take the skiagram from two directions, and if the antero-posterior one is taken stereoscopically, so much the better. Even with this assistance, it is often difficult to find a foreign body, such as a needle, and it is advisable to undertake the operation for its removal under the rays with the assistance of a screen. These are now made in a sterilizable form, so that full asepsis can be maintained.

The employment of complicated methods of localizing foreign bodies—*e.g.*, the cross-thread localizer—are not necessary except in ophthalmic work.

IV. **Gunshot Wounds.**—The character of a gunshot wound varies according to the nature of the projectile, the arm employed, the velocity of the missile, the distance from the body at which the firearm was discharged, the part of the body struck, and the direction of the shot.

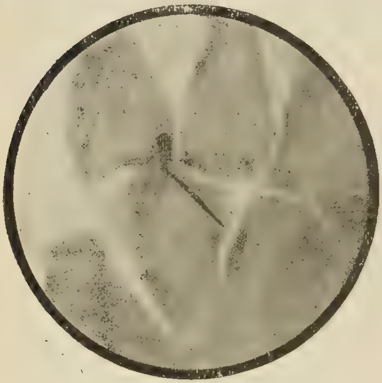

Fig. 78.—Skiagram of Wrist with Portion of Needle embedded in Palmar Aspect.

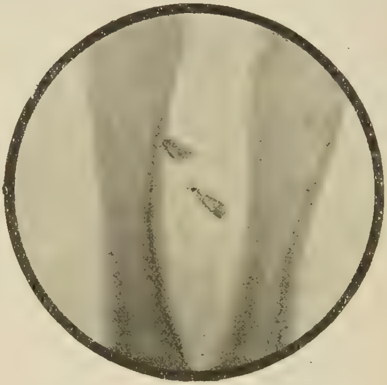

Fig. 79.—Skiagram of Hand with Splinters of Glass embedded Close to the Metacarpal Bone of the Index Finger.

It will be noted that the glass casts quite as dense a shadow as the bone.

The wounds inflicted by the **modern small-bore rifle** (*e.g.*, the Lee-Enfield, Mauser, or Krag-Jörgenson) are very different to those produced by the old-fashioned guns of former days. The modern rifle has been designed to secure great muzzle velocity, a low trajectory, and clean and hard hitting. To this end the barrel is rifled so as to cause the bullet to rotate on its own longitudinal axis (without such rifling the bullet would rotate on its short axis), and the bullet has been greatly modified, whilst gunpowder has given way to more highly explosive substances.

The modern bullet of the British Army is a long, thin, conical body, consisting of a core of lead hardened by the addition of 2 per cent. of antimony, enclosed in a cover, jacket or mantle made of a copper-nickel alloy. The muzzle-velocity is very high, amounting to 2,000 feet per second for a Lee-Enfield rifle, and 2,380 feet per second for a Mauser. The trajectory is nearly flat; anything within 500 yards may be fired at point-blank, whilst in a range of 2,000 yards the bullet only rises 194 feet, as compared with 866 feet with the Snider bullet.

The effect of these arms varies to some extent with the range; the worst wounds are usually produced at a short distance, say 500 or 750 yards, yet quite simple wounds with no disruptive phenomena may also be caused at a similar range. One of the best-marked features of these wounds is that the bullet travels straight and direct, without lateral deviation or deflection, as was so commonly the case in the old days. Simple flesh wounds are of no great importance *per se*, granted that important vessels and nerves are not injured. The aperture of entry is small, and looks somewhat 'like a bug-bite' (Treves); the aperture of exit is slightly larger, and tends to be a little more slit-like. A certain amount of extravasation occurs into the tissues around the track, but the external bleeding is often slight. There is but little tendency to carry in portions of clothing or septic material, and the bullet usually escapes; the wound heals by first intention if reasonable precautions are taken. The external cicatrices finally look very similar to those produced by bad acne pustules. Vessels and nerves are not likely to be injured unless they are actually in the line of the bullet; the accurate limitation of the damage to this line is evident when one hears of a bullet passing between the abdominal aorta and the vena cava without either being injured. If a large artery is cleanly hit, the patient bleeds freely, and may die of hæmorrhage, unless it can be controlled by a tourniquet. If the artery is button-holed, a traumatic aneurism may result; arterio-venous wounds have been common in recent campaigns. There has been some difference of opinion as to the character of the injuries to bones; that large masses of cancellous tissue (*e.g.*, the lower end of the femur) can be drilled cleanly without fracture is certain; but such wounds are sometimes associated with much splintering and involvement of neighbouring joints, possibly as a result of a short range, or of expansion of the bullet from the tearing down of the mantle. If a bullet hits cleanly the compact shaft of a long bone, it may smash the whole bone into small fragments, or the force may be more localized in its action, though always severe. Such comminuted fractures are very likely to become infected, if there is a long transport to the field hospital, and then fragments undergo necrosis and serious inflammatory phenomena follow.

Head wounds are much less fatal than might be imagined from the experimental work that has been undertaken. At close range frightful disruptive effects are produced which are almost certain to be fatal; at a longer range comparatively little mischief is done, except along the line of the missile. The inner table is always more splintered than the outer, and of course a certain amount of brain substance may escape. Abdominal wounds are also much less serious than formerly, a mortality of 90 per cent. (American Civil War) being replaced by one of 40 per cent. in the South African campaign, and that without operation (Treves). The mere penetration of one or more coils of intestine is not sufficient to cause general peritonitis; the wound is very small, and peristalsis seems to come to an end entirely as soon as the patient is struck, so that neighbouring coils of intestine or the omentum suffice to prevent fæcal extravasation; indeed, many of the patients suffer but little constitutional or local disturbance. Of course an empty intestinal canal is a favourable condition, and this is not unfrequently present on the field of battle. Bloodvessels may be wounded in the mesentery, and death result from hæmorrhage; solid viscera, such as the liver or spleen, are often damaged but little, granting a fairly long range.

On the whole, the effect of these modern bullets is comparatively slight, unless a vital part or a long bone is struck, and hence their ‘stopping’ power is defective, especially in dealing with the mad rushes of savages or fanatics. Modifications are in progress, so as to secure a more effective disabling of a man when hit without resorting to such contrivances as soft-nosed bullets.

Soft-nosed Bullets (*e.g.*, the Dum-Dum) are characterized by the mantle being absent at the top, whilst the lead core is usually free from antimony. The result of this is that as soon as the bullet strikes, the lead core mushrooms out, and terrible mutilation or destruction of surrounding tissues ensues, whilst bones are comminuted and solid viscera pulped. A similar result follows from rubbing or cutting off the top of the Lee-Enfield or Mauser bullet, or even from incising the cover in two or three places. These bullets are ‘expanding’ and not ‘explosive’ in character; the latter property can only be secured by including some substance which detonates on impact.

Martini-Henry and Snider Bullets produce wounds which are intermediate in their severity between the preceding two. The aperture of entry is usually small, that of exit large and with everted edges. Portions of clothing are frequently carried in by these missiles, and add to the risks of infection.

Shell Wounds have no special peculiarities beyond their severity and the ghastly nature of the injuries which may be inflicted by them, depending on the irregular shape of the fragments into which the shell bursts.

Revolver Wounds are more likely to be seen in civil practice than any other form of gunshot injury. They may be suicidal or accidental in origin. *Suicidal* wounds are usually directed to the temple, the base of the skull through the mouth, or the heart. In the temporal region (right side for right-handed individuals) there is usually a small wound, surrounded by an area in which the skin and hair are singed, and perhaps stained by the powder. The bullet pierces the bone and traverses the brain, but in the majority of cases does not emerge from or even fracture the other side. It may be found either embedded in the brain substance or loose under the dura mater. Death is not always instantaneous, as no large vessel may be torn. When the revolver is discharged upwards through the mouth, the base of the skull is penetrated, and death is more likely to be instantaneous; the bullet in some cases may dislodge a portion of the top of the cranium, but without penetration. *Accidental* revolver wounds may present any variety of lesion, but the apertures of entry and exit are distinctly recognizable as a rule.

Dangerous wounds may be inflicted by **small shot,** as, for instance, when one of the pellets enters the eye, whilst the wads or other portions of the cartridge may also be carried into the body; a horsehair wad may produce tetanus. A **blank cartridge,** if discharged at a short distance, may produce a severe wound or even death, and under such circumstances the skin around is likely to be burned and blackened, leaving a permanent bluish-black tattooing of the tissues.

The **Treatment** of gunshot wounds is conducted in accordance with general surgical principles, although it may have to be somewhat modified by the patient's environment and by the fact that after a battle the pressure of work may be such that all lengthy operative procedures have to be discarded. The first essential is to protect the wound from infection, and for this purpose the small packet of antiseptic dressing carried by all our soldiers is admirable. Bleeding is controlled by a tourniquet, and splints must be improvised for broken limbs. As soon as the wounded man reaches the field hospital, the wound is more thoroughly explored and cleansed; foreign bodies are removed, bleeding-points secured, and if the bullet has not escaped and can be readily detected, it should be extracted. When lodged deeply, its position may be determined by skiagraphy, or by such appliances as Nélaton's porcelain-ended probe, or more complicated electrical contrivances, such as the telephone probe. Comminuted fractures are carefully investigated, detached fragments of bone are removed, and if an attempt is made to save the limb, splints, etc., are carefully applied. Primary amputations for bullet wounds are not very common at the present day, except when great comminution of bone or hopeless involvement of vessels and nerves has occurred. Wounds of the skull always demand the most careful attention, even when the bullet has penetrated cleanly and escaped; each opening must be trephined so as to allow of the removal of depressed splinters of the inner table. This rule holds good even when a bullet has merely ploughed a groove or track along the calvarium without penetration.

The treatment of abdominal wounds produced by small-bore rifle fire is generally one of expectancy. It has now been abundantly proved that patients can recover in the most astonishing fashion from bullet wounds which have traversed the abdomen from side to side or from front to back, and therefore unless there is some very clear indication, operation is better avoided. Moreover, the practical difficulties connected with abdominal sections, the frequent lack of sterilized water, of towels, and the dirty condition of the patient, together with the length of time that such an operation takes—all these constitute reasons for not interfering unnecessarily. Abdominal distension from hæmorrhage is one of the chief indications for laparotomy.

For revolver wounds very similar rules of treatment hold good. As a general rule, careful antisepsis to the external wound is all that is required; the bullet may be disregarded, and there is no need to attempt its removal, unless it is superficial or doing some mischief. Wounds in the limbs should not be explored unless vessels or nerves have been injured. On the other hand, cranial injuries always demand exploration of the aperture of entry and a limited search for the bullet. Abdominal wounds should also be opened up and investigated, if it is thought likely that some hollow viscus has been injured or internal hæmorrhage is proceeding.

V. **Poisoned Wounds.**—The great majority of poisoned wounds are due to some definite micro-organism, and have been discussed elsewhere. A few only remain to be dealt with here.

Stings of Insects, such as bees and wasps, are exceedingly painful, but not dangerous, unless some local complication, such as erysipelas, supervenes, or the stings are very numerous, as when a swarm of angry bees settles on a person, or the part involved is such as to lead to serious swelling, as in the pharynx or tongue, œdema of the glottis possibly arising under such circumstances. All that is usually needed is the application of a weak alkaline lotion, whilst a common and efficient domestic remedy is a freshly sliced onion applied to the part. Care must also be exercised to ascertain that the sting and poison sac are not left in the body.

Some varieties of flies and spiders are also extremely virulent, and the former play an active part in the transmission of many types of disease. Thus various forms of infective cellulitis or lymphangitis may be caused by the bite of a fly that has been feeding on putrid carrion, whilst the epidemic diarrhœa of children in summer is largely due to the infection of their food by flies. The tsetse fly in South and East Africa is the carrier of the virus of sleeping-sickness. Mosquitoes and midge bites are exceedingly irritating; one variety, the female of the Anopheles, is the active agent in transmitting the virus of malaria, and another is responsible for the development of filariasis. Fleas carry the *B. pestis* from infected rats to the human subject, giving rise to plague, and it is probable that bed-bugs are similarly harmful.

Chigoe, or the jigger, occurs in many parts of the tropics as a result of the activity of the sand-flea (*Pulex penetrans*). The female, when impregnated, fixes herself by the head to some portion of the skin, preferably of the sole of the foot, or under the nails, and proceeds to burrow between the dermis and the epidermis, producing thereby a peculiar stinging pain, which is very characteristic. The head remains fixed in the deeper part of the pocket, whilst the abdomen becomes greatly distended in the course of a few days, constituting a sac, containing a large number of eggs. Great irritation is caused thereby, and inflammatory phenomena, with perhaps swelling of lymphatic glands, especially if the sac is crushed or burst. Left to itself, the ova are set free, and escape externally to develop into vermiform larvæ. **Treatment** consists in enlarging the burrow by means of a blunt needle or probe, and digging out the jigger complete, taking care not to burst the sac. The small opening is touched with tincture of iodine, but if suppuration is present, fomentations will be required.

Snake-bites require but little notice here, as they are exceedingly rare in this country, the common adder (*Pelias berus*) being the only venomous one likely to be met with, and even with this the poison is not sufficiently virulent to do much harm unless the individual attacked is a child or a person in a very bad state of health. The poison is conveyed to the wound from the glands and poison sac situated on either side of the upper jaw through fine canals in the specialized teeth, which open at their apices; these teeth are so delicate in some snakes that it may be difficult to find the wounds produced by them. The effects of an adder's bite are not, as a rule, noticed immediately, but come on in the course of an hour or so; extreme prostration supervenes, with a weak pulse, cold clammy perspiration, dilatation of the pupils, and perhaps delirium in bad cases, merging into coma.

The **Treatment** consists in preventing the absorption of the virus by tying a ligature firmly above the wound, which should then be laid open so as to allow of free bleeding, and the surface excised or cauterized. The collapse resulting from absorption of the poison is best remedied by the administration of stimulants or the hypodermic injection of strychnine.

In India and other countries many varieties of poisonous snakes are met with, and wounds are frequently fatal; indeed, in India it is stated that 12,000 individuals are yearly destroyed in this way. The symptoms come on rapidly, and are extremely severe, although they are modified according to the variety of snake. Treatment consists in the immediate application of a ligature round the limb above the wound, which is excised, or squeezed and sucked after incising, so as to encourage bleeding. The wound is then packed with crystals of permanganate of potash, or soaked in a concentrated solution of the same or of peroxide of hydrogen. If the patient survive, the ligature is removed from the limb after a few hours.* Strychnine and stimulants are required to counteract the depressing effects of the poison, and Calmette's antivenene, if obtainable, may also be employed; it consists of the blood-serum of a horse that has been immunized by the injection of gradually increasing doses of cobra venom. The dose required varies with the size of the snake—from 10 to 40 c.c. or more—and to be beneficial must be injected within an hour of the bite.

The **Anatomical Tubercle,** or **Butcher's Wart** (*Verruca necrogenica*), consists in a papillomatous development usually on the knuckles or wrists of those who are exposed to wounds either in the deadhouse or slaughter-house. It is in all probability a manifestation of tuberculous infection, and, indeed, resembles somewhat closely the appearance of lupus when it develops on the hands. Treatment consists in the application of a powerful caustic, whilst in bad cases it is necessary to scrape the surface before cauterizing.

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* Leonard Rogers, *Brit. Med. Jour.*, November 11, 1905.

Poisoned Wounds of the Fingers are not uncommon, arising from the infection of pricks, scratches, and abrasions, and sometimes giving rise to serious consequences, and especially when the patient's occupation brings his hands into contact with infective material. The dissecting-room used to be a fertile source of infected fingers, but the care now taken in the preparation of the cadaver has almost abolished this form of trouble. Pathologists and the attendants in the post-mortem rooms are liable to infection of this kind in spite of the use of rubber gloves; surgeons operating on cases of septic peritonitis, or nurses, especially when attending patients suffering from puerperal fever, may also be infected by pricking the finger with a needle or pin. The resulting lesions vary much in their character, from a mild suppurative folliculitis to various forms of inflammation of the nail matrix or subcutaneous tissues (constituting a whitlow), whilst the worst cases may develop a grave cellulitis, with perhaps suppuration of the axillary glands and septicæmia. Most of these conditions are described elsewhere, but it will be convenient to deal here with the subject of whitlow. (For Affections of the Nail Matrix, see p. 407.)

A Whitlow (*Paronychia* or *Panaritium*) occurs in four different forms, of which one is a localized inflammation of the skin, another a true cellulitis, a third is a teno-synovitis, and the fourth involves the terminal phalanx.

(*a*) The **Subcuticular** whitlow (or purulent blister) consists merely in a development of pus beneath the cuticle which separates it from the cutis vera. It is painful, but otherwise of little importance. A boracic fomentation, preceded by the removal of the loose cuticle, is all that is needed in its treatment.

(*b*) The **Subcutaneous** whitlow is a true cellulitis, commencing in the pulp of a finger, but often spreading upwards to involve the palm. The finger becomes swollen and painful, the pain being increased by pressure or by hanging down the arm. Gradually both these symptoms increase in amount, the back of the finger becoming œdematous, and the pulp more or less red. The swelling is at first hard and brawny, and even when pus is present it may be difficult to detect fluctuation unless the abscess is nearly pointing. Constitutional symptoms are not, as a rule, very severe, though the intensity of the pain may exhaust the patient. The hand should be elevated, and the finger fomented or poulticed, or treated by Klapp's suction-balls. When pus has formed, a free longitudinal incision in the middle line should be early adopted; but, though free, it must not extend too deeply, or the tendon sheath may be opened and infected. Occasionally the pus forms at one or other side of the finger, and the incisions must then be suitably modified. Antiseptic fomentations constantly changed and baths must be utilized after such an incision, the constant moisture adding greatly to the patient's comfort. Bier's plan of treatment may advisably be repeated after incision.

(*c*) The **Thecal** form of whitlow is really a suppurative tenosynovitis of the flexor sheaths. The signs are much the same as in the former variety, only more severe, because the process is often more extensive. As special features may be mentioned, the inability of the patient to bend the finger, and the extreme pain caused on attempting to extend it, owing to the involvement of the tendon and its sheath. The swelling also is more marked, and often extends to the dorsum of the finger, where localized collections of pus form a communication with the sheaths by a narrow neck; these are due to the yielding of weak spots in the postero-lateral aspects of the sheath. Infection of the inter-phalangeal joints, or even of the bones, resulting in caries or necrosis, may occasionally follow.

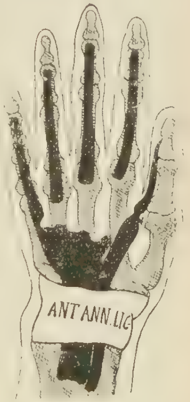

FIG. 80.—DIAGRAM OF SYNOVIAL SHEATHS OF FLEXOR TENDONS OF HAND.

Extension to the palm, and even to the forearm, is very likely to occur, owing to the arrangement of the tendon sheaths (Fig. 80); this is almost always the case when the little finger and thumb are involved, as the sheaths run along the tendons under the annular ligament. (In the little finger, however, there is sometimes a short break in the continuity, which is easily overstepped.) With the other fingers there is a definite gap between the tendon sheaths and the main palmar sheath (or bursa), and hence extension upwards is due to a proximal rupture of the sheath and infection of the connective tissue space in the palm, where it may be limited, or whence infection may spread to the palmar bursa or directly into the forearm under the annular ligament. Involvement of the palm is recognised by the part becoming swollen and tender, whilst the general symptoms are aggravated. The intercarpal articulations may be secondarily affected, and necrosis or caries of carpal bones, especially of the os magnum, may follow.

Extension to the forearm is usually due to infection of the tendon sheaths, but may spread along the connective tissue planes. The annular ligament constitutes an unyielding barrier, above which the forearm becomes swollen, hard, and brawny. The pus usually follows a definite course, being placed between the tendons of the flexor profundus and the pronator quadratus, and then travels up in close proximity to the interosseous septum along the median nerve or ulnar vessels.

Lymphatic infection may be associated with any of these manifestations, in the form either of an acute lymphangitis or acute inflammation of the epicondyloid or axillary glands, in the latter instance being perhaps associated with an axillary cellulitis. Naturally the constitutional results will be greatly increased by these complications.

Free and early incisions are required either in the middle line or on either side of the finger in order to secure effective drainage of the sheath, and thereby to prevent as far as possible the formation of adhesions, or to keep the tendons from sloughing. It may suffice to limit the incisions to the interarticular segments of the fingers, but frequently it will be necessary to make an incision the whole length of the finger. Extensions to the dorsum must be treated by counter-openings. If the connective tissue space of the palm is involved by extension from the index, middle, or ring fingers, the incisions employed in dealing with these sheaths must be carried up into the palm, but precautions must be taken not to infect the sheaths of the thumb and little finger. As a rule this palmar incision need not encroach on the superficial palmar arch, but even if it does it is of little consequence, as the vessel is easily secured. Involvement of the thumb and little finger will require more extensive incisions for satisfactory drainage (Fig. 81), whilst extension to the forearm will involve opening up the deep space between the flexor profundus and the pronator quadratus, and this is best accomplished by lateral and not by central incisions, the more superficial tendons being drawn forwards. In addition to effective drainage, fomentations will be required, as also immersion from time to time in hot baths; and when the discharge of pus is lessening, Bier's hyperæmia induced by the application of a rubber bandage above the elbow will be most beneficial. The usual constitutional treatment for an infective disease will be needed, and the patients usually require much improvement of their general health.

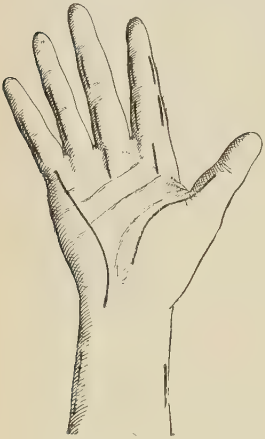

Fig. 81.—Incisions for dealing with Various Forms of Whitlow and their Extensions into the Hand or Forearm.

Unfortunately, however, patients often come under observation late in the case, and the mischief often extends in such a manner and to such an extent as to render amputation the only feasible method of treatment.

(*d*) The **Subperiosteal** whitlow may be merely a complication of the thecal variety; but it occasionally starts as an acute necrosis of the terminal phalanx, arising either idiopathically or as a result of infection from the nail matrix. The inflammation may be limited to the end of the finger, or may spread to the palm. Free incisions, and the removal of the bone, if dead, are necessary, followed by antiseptic fomentations or baths.

Repair of Wounds.

When any of the tissues or solid organs have been divided or injured, the reparative activities of the body early assert themselves in order to make good the defect, unless they are for a time diverted by the necessity of overcoming an invasion of bacteria, and even then the means employed by Nature to conquer the microbes are useful in determining the early stages of repair. It matters little what tissue of the body is involved, for in all the reparative process is the same, although modified somewhat by the local conditions In the majority of cases the ultimate result is a production of cicatricial or scar tissue, which serves as the bond of union between the divided structures, and varies in amount with the closeness of approximation, the maintenance or not of rest to the part, and the degree of inflammatory disturbance in the wound. In a few tissues a further stage—viz., that of regeneration of the injured parts—is reached; in this there is a preliminary formation of granulation tissue, which is subsequently invaded and replaced by a development from the parenchyma of the affected tissue or organ, but this can only occur when the parts are accurately brought together and perfect asepsis is present. Striped muscle, bone, tendon, nerves, and some glandular structures may thus be regenerated; the skin and subcutaneous tissues, rarely; the spinal cord, never.

The **general facts as to the process of repair** may be stated as follows: The margins of the wound are always bounded by an area of tissue in a state of lowered vitality, even if no bruising or sloughing of the parts is present. The divided vessels are in a condition of thrombosis as far as the next patent branches, which in their turn are slightly dilated, partly as a result of this obstruction and partly from the reflex irritation of the injury. The surface of the wound is generally covered with a film of lymph or blood-clot, whilst any spaces left in the interstices of the tissues are similarly occupied.

(*a*) The first stage in the process consists in an abundant *exudation of small round cells*, presumably leucocytes, whose function is to remove all dead or damaged tissue, as well as to break up, disintegrate, and finally absorb, any blood-clot which is present. After their work is completed, they disappear, either finding their way back into the circulation, or being destroyed by the fibroblasts. These cells are derived from the surrounding vessels, and are accompanied by a certain amount of plasma, so that the early manifestations of a slight inflammatory reaction are simulated, and this, if it does not extend beyond certain limits, is a beneficial proceeding. If much tissue has to be absorbed, or when a foreign body such as a suture is buried, giant cells are likely to make their appearance.

(*b*) The exudation of leucocytes is soon followed by the appearance of a number of large oval cells with abundant protoplasm and large vesicular nuclei, known as *fibroblasts*. These cells are mainly derived from those composing the tissues of the part, either from the connective-tissue corpuscles or the endothelial cells lining the capillaries, lymphatics, or lymph-spaces. The ingenious researches of Zeigler and his school, who inserted into the peritoneal cavity glass chambers composed of two pieces of thin cover-glass, cemented a short distance apart, and watched the process of organization in this narrow space, have shown definitely that some at least of the fibroblasts are wandering cells derived from the blood: it is possible that these cells are in their turn derived from the endothelium, and that the endothelial cell is the fibroblastic cell *par excellence*. Whatever their origin, they soon form a layer of cellular tissue which lies upon the surface or between the lips of the wound, whilst the previously effused leucocytes disappear.

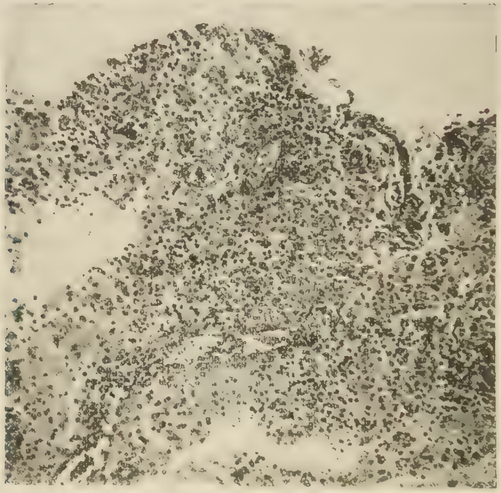

FIG. 82.—GRANULATION TISSUE FROM THE BASE OF AN ULCER. (× 60.)

(*c*) The *vascularization* of this cellular layer forms the next stage in the process. This is brought about by the outgrowth from the walls of the nearest capillaries of solid rods of protoplasm (Fig. 83, *a*), which appear first as minute buds, but rapidly increase in length, and may be single or double. They soon bend over to unite with similar threads growing out from other capillaries, or with the wall of another vessel (Fig. 83, *b*), or occasionally they unite with the vessel from which they started. After a time these protoplasmic threads become canalized (Fig. 83, *c*), and a communication is established between them and the mother vessel, so that blood passes into them. The new capillary wall, at first homogeneous, soon becomes lined with definite endothelial cells, and strengthened by connective tissue derived from the fibroblasts around. By this means a soft vascular tissue is produced, known as *granulation tissue* (Fig. 82), consisting of loops of capillaries supported by large nucleated cells with a varying amount of intercellular substance, which becomes fibrillated in texture. The capillary loops arise in leashes from small terminal arterioles, and it is to this arrangement that the granular appearance of the developing tissue is due; each granulation, as it arises, is about the size of a pin's head.

(*d*) The *transformation* of this granulation tissue into *fibro-cicatricial tissue* is next proceeded with. The fibroblasts become spindle-shaped, and finally long and narrow, with pointed extremities, which often branch (Fig. 84); the nuclei also become long and narrow, and lose their vesicular appearance. Around them is developed a fibrillated structure of a collagenous material, which is finally transformed into the fibrous tissue of the scar; the actual arrangement of this material varies with the physical characters and condition of the wound. By the contraction of these fibres the fibroblastic cells become flattened out and compressed, and the newly-formed vessels constricted, so that as time passes the scar tissue becomes less and less vascular, and consequently firmer and denser, as well as smaller.

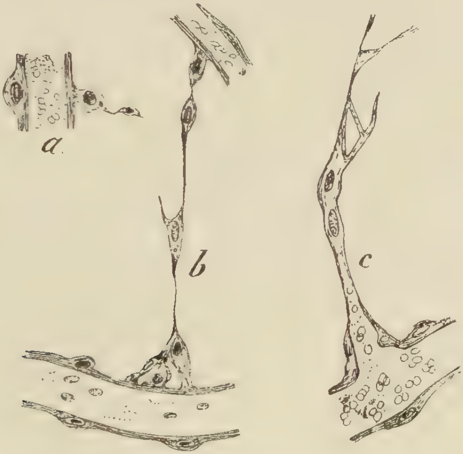

FIG. 83.—NEW VESSEL FORMATION. (AFTER TILLMANNS.)

a, A small bud-like projection from the wall of a capillary; *b*, the union of such buds one with another; *c*, the canalization of these processes.

(*e*) Whilst this last stage is in progress, the surface of the wound is covered over with cuticle, which spreads inwards from healthy epithelium in the neighbourhood of the wound, and especially from the deeper layers of the rete Malpighii.

As already stated, the general process of repair sketched above is modified according to the character and condition of the wound The following modifications are met with in surgery:

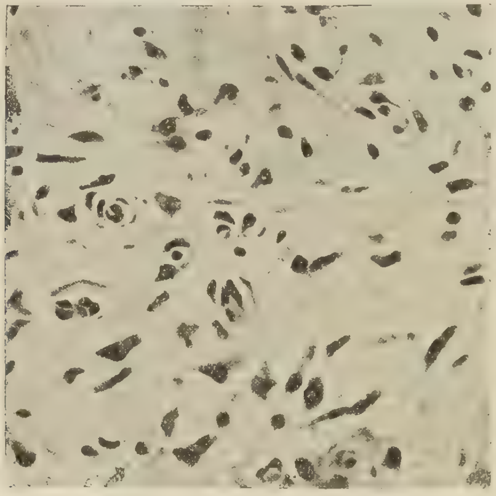

FIG. 84.—GRANULATION TISSUE IN PROCESS OF ORGANIZATION. (× 250.)

1. **Healing by First Intention** or **Primary Union** occurs in cleanly-cut aseptic wounds where the lips are unbruised and brought together, so that no extensive collection of blood or discharge between them is possible. A thin layer of blood-clot lies between

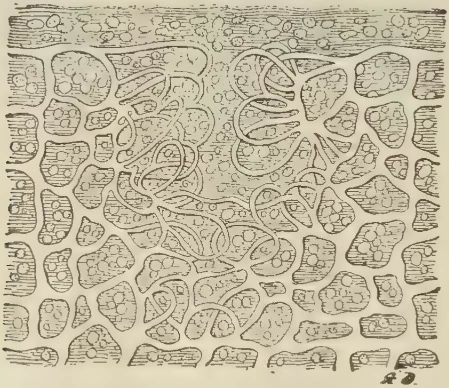

FIG. 85.—DIAGRAM OF HEALING BY FIRST INTENTION. (AFTER BILLROTH.)

The wound is occupied by a fibro-cellular growth, into which loops of capillaries extend, constituting granulation tissue, whilst the epithelium has united across the surface.

the surfaces of the wound and penetrates into their irregularities, and the contraction of this clot is at first the chief means of keeping the deeper parts in apposition. There is but a microscopic line of damaged tissue, which, together with the blood-clot, is easily absorbed, and the process runs a typical course, as sketched out above, union being effected in five to seven days. (See Figs. 85 and 86.)

2. **Healing by Granulation,** or **Second Intention,** as it used to be termed, is met with (*a*) in cases where there has been definite loss of substance, so that the lips of the wound are not, or cannot be, approximated; as also (*b*) when the surface of the wound is bruised or damaged so that portions of tissue have to separate by sloughing; or (*c*) when the advent of infection has prevented the occurrence of primary union.

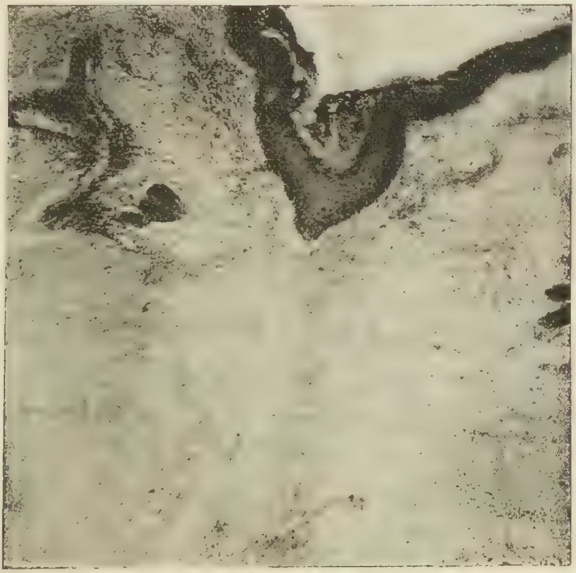

FIG. 86.—SECTION OF A WOUND HEALED BY FIRST INTENTION TEN DAYS AFTER ITS INFLICTION.

The epithelium is drawn in to form a V-shaped notch, and beneath is a mass of fibro-cicatricial tissue with comparatively few cells or vessels evident.

When a small amount of aseptic dead tissue is present, it is removed, as previously described (p. 109), by an invasion of leucocytes from the surrounding vessels, which disintegrate and gradually absorb it. These are followed by the fibroblasts, which form a layer of granulation tissue on the surface of the wound (Fig. 87). If there is much slough to be dealt with, the vitality of the granulation tissue cannot be maintained beyond a certain distance from its source of nutrition, and so by a process of simple anæmic ulceration the unabsorbed dead portion is cast off and a granulating surface remains. If bacteria are present in the slough, inflammation occurs in the adjacent living tissue, and this brings about a similar result, though accompanied by suppuration and fever.

When, however, there is a simple loss of substance, with no bruising or infection of the tissues, the course of events is as follows: The blood-stream in the superficial capillaries having been arrested, adjacent vessels become dilated, and from these an exudation of plasma and leucocytes results. The plasma coagulates on the surface and forms a layer of fibrin, entangled in the meshes of which are a number of white corpuscles, so that the wound becomes covered with a film of whitish-yellow material known as lymph. This gradually increases in amount and thickness, and is vascularized from below into granulation tissue, this process occupying from four to seven days.

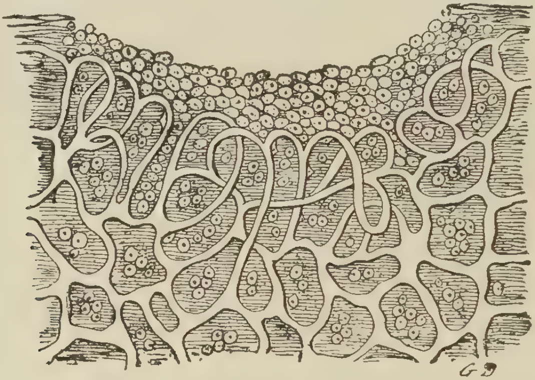

Fig. 87.—Diagrammatic Representation of Healing by Granulation (After Billroth.)

The healing of a granulating wound is brought about by the conversion of the granulations into fibro-cicatricial tissue, and by the surface becoming covered with cuticle. The contractile tendency inherent in all cicatricial tissue produces two results from its presence in the base of the wound beneath the superficial layer of granulations: (i.) The surface area of the wound is diminished in all directions, a most important element in the healing process, since if the base is adherent to some dense resisting structure repair is slow and difficult. When the granulating surface is very extensive, contraction may proceed to such a degree as to obliterate many of the vascular channels, and by thus depriving the superficial tissues of their adequate nutrition, the healing process may be indefinitely prolonged. (ii.) The depth of the wound is diminished, partly by the continuous growth of granulation tissue from below upwards, but mainly by the contractile base lifting the deeper structures to the surface. If the base of the wound cannot be raised, the superficial parts are drawn down, and the cicatrix is usually depressed and adherent to the underlying parts.

During the process of repair the wound takes on the appearances already described as characteristic of a healing ulcer (p. 105).

It is sometimes possible to hasten the healing of an extensive granulating wound by drawing together the two margins so that the two surfaces are brought into apposition. Exudated lymph sticks the surfaces together in the first place, and subsequently granulations develop and bridge the gap. This **union of granulating surfaces** is often helpful in the closure of abdominal wounds left by the drainage of deep abscesses.

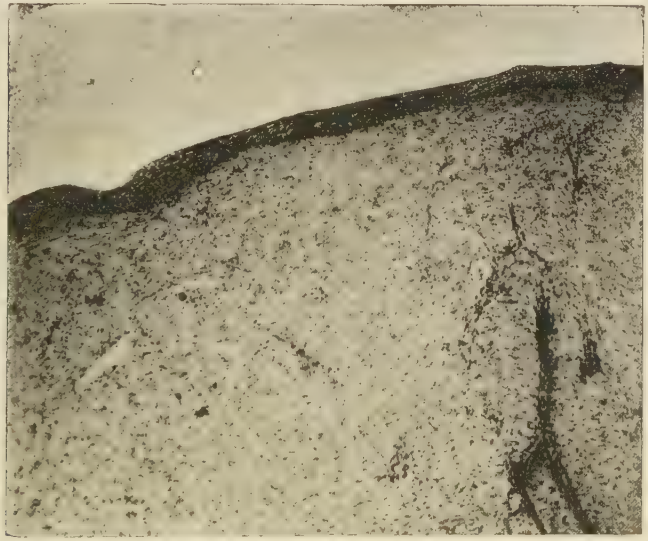

FIG. 88.—SCAR FROM A RECENTLY HEALED SUPERFICIAL WOUND. (LOW POWER.)

The epithelial surface is regular and devoid of papillæ; the scar tissue has an abundance of cells scattered through it, as well as some very obvious vessels, which would almost entirely disappear at a later date.

3. **Healing under a Scab** is a proceeding that can only take place in very small wounds, such as superficial grazes and abrasions, and is practically identical with the granulating process, except that, instead of an artificial dressing applied by the surgeon, the lesion is covered by a scab which consists of clotted blood or dried exudation. Should infection be present, pus is likely to accumulate beneath the scab and may cause trouble.

4. **Healing by Organization of Blood-clot** can only be watched in strictly aseptic wounds where there is definite loss of substance, as in the deep channels sometimes made in the treatment of bones

thickened by chronic osteitis, but of course it occurs in all subcutaneous wounds where there is effusion of blood. The dark coagulum shows no trace of change for some days, but gradually the peripheral portions become granular and yellowish-white in colour; granulations appear in this peripheral portion, and in time spread through the whole mass from periphery to centre, and then repair occurs as described above. The clot is absolutely passive in this process, being infiltrated by leucocytes and removed by degrees, and thus merely serves as a basis of support or scaffolding for the building up of the granulation tissue which replaces it. A similar result may be obtained by filling a cavity with grafts of sterile sponge or decalcified bone.

5. **Healing of a Detached Portion of the Body** is not unfrequently seen when parts of the nose, external ear, or finger-tip, are separated. The loose portion is carefully cleansed, reapplied accurately, and fixed firmly, though gently, into position. If it lives, union occurs by first intention; if it dies, but remains aseptic, it constitutes a cover or scab, under which healing by granulation occurs.

A **Scar** is a mass of fibroid tissue covered by epithelium, which has been formed in the repair of a wound (Figs. 86 and 88). It is at first vascular, and contains cells of the connective-tissue type; but after a time, as contraction continues, the cell elements become flattened out, fewer in number and less obvious, the intercellular fibrous tissue more abundant, and the vessels constricted, so that finally a scar becomes well-nigh bloodless. Where superficial, its colour changes from red to white, and if of small size it may almost disappear, but never absolutely, unless the subcutaneous tissue has not been involved. When the parts around become injected by any cause, such as sharp friction, the anæmic scar tissue again becomes evident by contrast. Lymphatics, nerves, hairs, and cutaneous glands are all absent, except perhaps at the periphery, and the epithelial covering itself is merely a uniform layer without papillæ.

The **Pathological Phenomena** connected with scars are as follows:

1. **Excessive Contraction,** which may lead to great deformity, especially when the wound has occurred in the flexure of any of the joints. A web-like mass of fibroid tissue then forms, limiting movement, and requiring operative interference. A seriously burned hand may by cicatricial contraction be fused into an unsightly mass, rendering the fingers of little use; similarly, the chin may be drawn down and practically fixed to the sternum, and the lower lip everted, as the result of a burn on the front of the neck. The *Treatment* of such conditions consists in dividing or excising the cicatrix, and thus freeing the parts, during which process it must be remembered that deeper structures of importance, such as the main vessels and nerves, may be adherent to the under surface, and thus be endangered. When once the scar has been divided, there is often no difficulty in restoring the parts to their normal positions, although when the contraction has existed for any length

of time it may be advisable to do this slowly, even by gradual extension with a weight and pulley, so as to avoid the risk of lacerating the deeper parts, which are usually contracted secondarily. The raw surface thus produced is covered with epithelium by Thiersch's method or Wolfe grafts.

Of recent years it has been proposed to treat such cases by injections of thiosinamin or fibrolysin,* administered hypodermically. A solution of 10 parts of the drug in 20 parts of glycerine and 70 of distilled water, is apparently the best, and in the adult the dose may range upwards from ½ c.c. Interesting results have been published of cures of many different conditions due to developments of scar tissue, and it is supposed that they are due to an active leucocytosis induced by the drug. Possibly the internal administration of iodolysin (an ethyl-iodide of thiosinamin) may be even more useful. Care must be taken in the use of this remedy in old people, as it is impossible to limit its action to the scar that it is desired to soften. Cases have been known in which the walls of arteries in a condition of arterio-sclerosis have been acted upon, and the patient's death resulted from purpura or cerebral hæmorrhage.

2. **Overgrowth of the scar tissue** is sometimes met with, constituting what is known as the false or **Alibert's Keloid** (Plate II., Fig. 2). This most frequently occurs in the scars of burns or of wounds in tuberculous patients, but may arise from any cicatrix, presenting itself as a fibroid indurated mass of a dusky red colour, with perhaps a number of dilated vessels coursing over it, which occupies the region of the old scar, and may possibly send claw-like processes into neighbouring healthy structures. It consists merely of a hyperplasia of the scar tissue, but as to its ætiology nothing is known. With the exception of somewhat severe pruritus or itching, its presence entails no inconvenience, although if it occurs on exposed parts it may be very disfiguring. Removal is useless, since the keloid almost always recurs in the new cicatrix and in the stitch holes. After a longer or shorter interval it often disappears spontaneously. Exposure to X rays or to radium is beneficial in these cases, although the treatment may be of long duration.

3. **Ulceration of Scars** is usually an evidence of defective nutrition, or of local irritation. It is always chronic and difficult to heal. Local protection and stimulating applications, together with general tonic treatment, are required.

4. **Painful Scars** arise from either the implication of a nerve terminal in the cicatrix, or the pressure of a contracting scar upon the bulbous end of a divided nerve, as in amputation stumps. The pain is often very persistent and wearing, and may radiate widely. Operation is usually necessary in order to free the nerve from the scar tissue or to excise it.

5. **Malignant Disease of Scars,** or of old chronic sores but partially healed, is of an epitheliomatous type, and appears as a hard ulcerated

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* Thiosinamin is prepared by warming oil of mustard with an alcoholic solution of ammonia. Fibrolysin is a mixture of thiosinamin with salicylate of soda.

tumour with everted edges and a thickened base (*Marjolin's ulcer*). The progress is very slow, since the vascularity of the tissue is slight. It is painless, from the absence of nerves, and as long as the disease is limited to the scar, no lymphatic implication will be noted. As soon, however, as the malignant growth invades healthy tissues, the usual phenomena show themselves. The diseased tissues, which are often very dirty and offensive at first, may be freely dissected out, having regard to subjacent structures, and the wound closed by some plastic method, or amputation may be required.

General Conditions connected with Wounds.

I. **Shock.**—By the term 'shock' is meant a general depressed condition of the system associated with a marked fall of blood-pressure, resulting from the transmission of some energetic stimulus to the vital centres in the medulla, either from the peripheral sensory or sympathetic nerves of an injured part, or from the emotional centres. **Local Shock** is a curious condition of insensibility to pain on handling, which is sometimes present after severe injuries, and is especially seen in gunshot wounds. Possibly it is due to some temporary paralysis of the sensory nerves.

The term **collapse** is applied to a condition very similar in nature to shock, but differing from it mainly in its onset, which is gradual, and often preceded by some exhausting disease, and by the fact that muscular relaxation is more complete. The collapse of cholera is one of the most typical manifestations, but any condition associated with loss or derivation of fluids from the vessels may give rise to it—*e.g.*, prolonged vomiting or serious hæmorrhage. If at the same time toxic absorption is taking place, the symptoms are still more marked; thus in acute peritonitis the two factors, removal of fluid from the circulation and toxæmia, are proceeding concurrently. Shock usually tends to recovery, unless the lesion is of a serious nature, and then collapse may supervene and prove fatal; thus, after rupture of the intestine the immediate symptoms are the result of shock, but they are quickly followed by the collapse due to acute peritonitis.

Our knowledge of this subject has been largely increased of late years by the researches of Crile in America, and J. D. Malcolm in this country, and it is now clearly recognised that the essential cause of shock is the division of, or injury to, the sensory or sympathetic nerves. Experimentally it is easy to demonstrate that a marked fall of blood-pressure results from dividing or crushing a sensory or mixed nerve, and that clean division is less harmful than bruising or crushing.

It is therefore obvious that the **degree of shock** will vary with the abundance or not of the supply of sensory nerves to the injured parts; organs like the testis, hand, small intestine, etc., will be productive of much shock when injured. *Cæteris paribus*, deep wounds are more productive of shock than superficial, but a very extensive superficial lesion may be more harmful than a limited deep one. Thus, a scorch or burn involving half the surface of the body is more productive of shock than the complete incineration of a hand or foot. Operations on the head or the brain are followed by comparatively little shock, whilst the upper part of the abdomen is more susceptible to depressing influences than the lower. Operations on the kidneys and urinary passages are associated with little shock.

The *character of the injury*, whether clean-cutting or crushing, is also important. Surgical operations which involve traction on important nerve trunks or centres are followed by a greater degree of shock than when nerves are simply divided; hence clean manipulations and the avoidance of rough bungling handiwork are preventives of shock.

Shock is also increased by anything that lowers the general tone of the body, such as loss of blood, exposure to cold, want of food, or toxic absorption.

The nervous susceptibility of the patient and the expectation or not of the injury are most important factors in the production of shock, for the more highly organized the nervous system, the greater is the amount of shock experienced, and *vice versâ*. When the whole nervous system is maintained in a state of tension, anxiously expecting the receipt of some painful impression, the effect produced will naturally be increased; whilst if the attention is diverted, and interest actively aroused in other things, the shock at the time is much diminished, though its effects may be subsequently greater. Thus, in the keen excitement and nervous tension of a battle, soldiers have often been wounded severely, and yet not known it at the time; whilst the pain of the most trifling cut may produce deep shock when the patient is in a state of dread and anticipation.

The **Symptoms** vary with the injury inflicted, from a slight momentary giddiness and faintness (closely simulating an attack of syncope or a fainting fit) to immediate and complete prostration, insensibility, and even death. The pulse, at first small and weak, soon becomes irregular, extremely rapid, and often imperceptible; the countenance is pallid and shrunken, and the brow covered with cold sweat; the respirations are slow and shallow, whilst the temperature is usually subnormal.

After an interval, the length of which depends on the severity of the lesion and the treatment adopted, *reaction* occurs, being introduced by increased depth and frequency of the respirations; the pulse becomes slower and fuller, the surface warmer, whilst consciousness and muscular power are gradually restored. During this period it is not unusual for an attack of vomiting to supervene.

Sometimes reaction is accompanied by irritability, either of the mental or muscular systems, in the one case leading to traumatic delirium, which is always of grave import, and in the other to intense restlessness, as in the shock which follows extensive burns. It is probable that both these conditions are largely due to toxæmia. The term *erethitic* shock is sometimes applied to these manifestations.

Occasionally the evidences of shock are delayed in their appearance for some time after the injury, and come on gradually. Especially is this the case after railway accidents when no great injury has been experienced; for a time the anxiety and excitement are such that no depression is noticed, but as the mental perturbation passes off, the individual experiences symptoms very similar to the above, but probably rather of the nature of neurasthenia than of real shock (see Chapter XXIV.). When an accident occurs to a person in a state of intoxication, it is not unusual for the phenomena of shock to be delayed for some time, only showing themselves when the effect of the alcohol has passed away.

Pathology.—The *post-mortem* evidences are not at all characteristic, and consist merely in anæmia of the brain and superficial parts of the body, and enormous engorgement of the abdominal viscera, lungs, and great venous trunks; the heart contains practically no blood, although it is probable that the right side is much distended at the time of death, especially when due to sudden injury, and subsequently empties itself by post-mortem contraction. The *explanation* of the phenomena of shock is by no means simple, and several factors are probably needed to produce the complex result. 1. Reflex inhibition of the heart's action through the cardio-inhibitory centre in the medulla explains the early syncope with slow pulse. It is well known that if a frog's abdomen is opened and the exposed intestine sharply struck, the heart stops in a condition of diastole, whilst if the vagi are previously divided, no effect is produced. Any severe peripheral injury may lead to such a result, especially those directed to the great sympathetic centres in the abdomen which are closely connected with the vital centres in the medulla. In this way sudden death may be produced by a severe blow in the epigastrium, or by drinking a glass of very cold water, when hot; but, as a rule, this inhibition of the heart's action is never prolonged in mammals. 2. The causation of the shock which follows lengthy operations is still a matter of discussion. Crile,* who has studied this subject experimentally, shows that stimulation of the central end of a divided sensory nerve causes a rise of blood-pressure at first; but if the stimulation is repeated often, this rise gradually diminishes, disappears, and in time is represented by a fall. This he attributes to exhaustion of the vasomotor centre in the medulla; the blood collects in the splanchnic area as a result of paralytic distension, and hence the supply to the brain and surface of the body is diminished to a dangerous degree. Obviously, any considerable hæmorrhage will aggravate the symptoms. In confirmation of this idea is the fact that previous cocainization of the nerve hinders the rise or fall of blood-pressure, evidently by blocking the upward extension of the stimuli. Crile's explanation has been recently questioned by Malcolm,† who points out that in lengthy abdominal operations with much shock this portal engorgement does not become obvious, and suggests that the cause of the shock is not paralysis or exhaustion of the vasomotor mechanism, but a gradually ascending contraction of the arteries from the surface towards the centre, which keeps the blood more and more in the central parts of the body, and deprives the periphery, and, finally, the brain itself, of its necessary blood-supply.

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* 'An Experimental Research into Surgical Shock,' by G. W. Crile. J. B Lippincott Co., 1899.

† 'Remarks on Shock,' *Brit. Med. Journ.*, December 9, 1905.

Diagnosis.—1. From the general results of *hæmorrhage*. Restlessness and thirst are then prominent signs, together with a sense of dyspnœa, causing rapid respiratory efforts; the mental condition, moreover, is less affected, and the patient is generally sensible; the surface is exceedingly blanched, and the pulse may have a marked hæmorrhagic wave. 2. In *concussion of the brain* there are superadded to the symptoms of shock those more particularly connected with the region affected, *i.e.*, the intellectual centres, so that unconsciousness is the predominant feature, whilst loss of memory of the accident and of the events which followed is often noticed. 3. When *vomiting* is approaching *under* the influence of *an anæsthetic*, the patient's pulse usually becomes weak and rapid, and the countenance pale. This condition closely simulates shock, and is often distinguished from it only by the progress of the case. Under such circumstances, if vomiting is plainly imminent, it is sometimes wise to increase the amount of anæsthetic, as the patient is usually not fully under its influence.

Treatment.—In slight cases very little is needed beyond resting quietly for a few minutes, or the exhibition of some aromatic stimulant to the nostrils, such as ammonia or smelling-salts. In the more severe cases the patient is laid recumbent, with the head low; hot bottles, well protected, and blankets are applied to the trunk and extremities to maintain and increase the bodily temperature. A very simple, but successful, plan of raising the bodily temperature is to place under the bedclothes, which are supported on a cradle, one or more electric lamps of such strength as to bring the temperature of the air around the body to 100° to 105° F. This has proved of much value in combating the severe shock following burns in children.

The injection of hot saline fluid (1 drachm of chloride of sodium to 1 pint of water) into a superficial vein, the rectum, or the subcutaneous tissues (submammary or gluteal, for choice), has been employed with considerable success of recent years. The *modus operandi* of intravenous or intrarectal infusion is described elsewhere; the fluid should be introduced at a temperature between 105° and 110° F. Where there has been much loss of blood, the intravenous infusion of 2 or 3 pints may be useful to begin with, but as a rule rectal infusion is sufficient.

According to Crile, a most valuable remedy for shock is the intravenous injection of a solution of adrenalin (1 in 50,000 or 100,000 parts of normal saline solution), a few cubic centimetres being allowed to enter the circulation each minute. Pituitary extract also has a powerful effect in raising the blood-pressure, and slowing the too rapid action of the heart in shock. Drugs, such as strychnine or digitalin, are not of much use, but a small enema of hot strong coffee is sometimes very valuable in tiding the patient over the period of depression. Alcohol is usually undesirable.

An important question is often raised as to the advisability of performing an operation during shock. As a general rule, it may be stated that operation should be deferred until reaction has come on, unless the presence of the injured organ, such as a badly crushed limb, is evidently prolonging the condition. Under these circumstances a hypodermic injection of morphia may improve matters by relieving pain; otherwise the local lesion should be at once dealt with, and it will be often found that, as the patient passes under the influence of the anæsthetic, the pulse improves, and the state of shock disappears, the anæsthetic shielding the medullary centres from the painful afferent stimuli.

Shock may to a large extent be *prevented* during operation by a careful attention to such details as not purging or starving the patient unduly beforehand, keeping him well covered and as warm as possible, by maintaining the temperature of the operating-room at not less than 70° F., by minimizing hæmorrhage, and by rapidity and cleanness of execution. A hypodermic injection of strychnine, or a brandy and beef-tea enema, given just before the operation, is also useful; and in nervous patients a dose of morphia will often blunt their nervous susceptibilities and protect them from shock. It must also be remembered that incomplete anæsthesia tends to increase the shock rather than to prevent its occurrence, although as little anæsthetic should be administered as possible, and in bad cases ether rather than chloroform. In any operation, where shock is likely to be severe, its development may often be prevented by commencing intravenous infusion before the operation begins, and continuing it slowly throughout, or by administering ether in conjunction with the saline solution. Spinal anæsthesia, when available, is useful in preventing shock, since it protects the medullary centres from afferent stimuli; but the question of the mental effect of the operation on the patient must also be considered; the abolition of consciousness is in many cases a most desirable condition. The recently introduced plan of inducing anæsthesia by the so-called *anoci-association* method, described in Chapter XLV., holds out hopeful prospects of eliminating largely the element of operation-shock.

II. **Traumatic Fever.**—Traumatic fever is that which follows the receipt of an injury, whether simple or compound, or after an operation. Two main varieties are described:

(*a*) **Aseptic Traumatic Fever** occurs after subcutaneous injuries, such as sprains, contusions, fractures, etc., and after aseptic operation wounds or compound injuries, where micro-organisms are absent or impotent. The cause is the absorption of fibrin ferment or some other chemical substance, which has a stimulating effect upon the thermogenic centres. Probably the use of irritating antiseptics in the wound, the retention of serous discharges, and the accumulation of blood, are the chief causes of the pyrexia. Occasionally fever is observed in cases where we have no grounds for supposing that absorption is taking place; it may then be due to some peripheral irritation, *e.g.*, a badly-fitting splint, and disappears immediately on the removal of the cause.

The symptoms are those of slight pyrexia, reaching 100° or 101° F. within twenty-four or forty-eight hours of the injury, with coated tongue, loss of appetite, etc., gradually passing off in three or four days. If thus limited, it is of no prognostic importance.

(*b*) **Symptomatic Traumatic Fever** is caused either by the absorption of the products of putrefaction, resulting from the vital activity of organisms in discharges, blood-clot, or dead tisue; or from the absorption of the toxins connected with a development of parasitic organisms in the wound or its surroundings; or from the supervention of some general infective disorder. All these different conditions have been dealt with elsewhere (p. 91).

III. **Traumatic Delirium.**—Although delirium is merely a symptom, it is occasionally of so pronounced a character as to demand special attention. Three forms are described:

(*a*) The **Active Delirium** which accompanies severe injuries, particularly in plethoric, and often in previously healthy individuals, whose environment has been suddenly changed from that of everyday life to a sick-bed in a hospital ward. Infection of the wound is usually present, and the delirious state is associated and runs a parallel course with the fever. It is not usually of a violent type, although the patient may be irrational and restless; he moves the injured part without any evident appreciation of the pain which, if conscious, he must suffer, but he is easily restrained by the exhibition of firmness and tact on the part of the attendant. The symptoms are most marked at night, and commence at the end of forty-eight hours, lasting, as a rule, for two or three days. There is a distaste for food, which, however, can be overcome by gentle persuasion.

Treatment.—Patients in this condition must never be left; the diet should be light, but nourishing; the bowels are thoroughly opened, and an icebag to the head may be useful. The wound should be freed from any purulent accumulation.

(*b*) **Delirium of a Low Muttering Type** is met with in individuals of low vitality, exhausted by dissipation, drink, disease, or faulty hygienic surroundings. It is commonly associated with fever of an asthenic type, such as is seen towards the end of infective diseases. The patient usually lies on his back, staring vacantly upwards, is incoherent, takes no notice of surrounding objects, and is observed to pick at the bedclothes and mutter to himself unintelligibly. There is often, in addition, an involuntary escape of urine or fæces, The mouth is generally open, the tongue dry, brown and cracked, and viscid mucus collects about the teeth (*sordes*).

The **Treatment** should be directed to careful nursing and feeding, as by that means alone can the patient be saved.

(*c*) **Delirium Tremens** is observed in individuals who, previously of intemperate habits, have suffered some serious injury, such as a compound fracture. The violent symptoms do not set in till about the third day, but are usually preceded by some amount of sleeplessness and wandering at night, or the patient may have short snatches of sleep, from which he awakes semi-delirious. This gradually increases, and is followed by violent delirium, in which the patient is haunted by terrifying visions of reptiles, horrible insects, and the like, from which he tries in vain to escape. During this stage of exitement he is with difficulty restrained from jumping out of bed; in many instances these patients are remarkably cunning, and, managing to elude the vigilance of their attendants, will succeed in escaping from the room by the door or window, and may inflict serious, and even fatal, injuries upon themselves or others. There is always a tremulous condition of the extremities and of the tongue, which is white and coated, whilst the bowels are obstinately confined. The pulse and temperature vary considerably, and the skin is often moist and clammy. The violent stage is always followed by profound exhaustion, in which the patient may gradually sink into a state of coma and die. In the case of a fractured leg, the struggles of the patient will cause considerable displacement of the limb, and necessitate constant attention to prevent further mischief. The limb should never be fixed to the bed, but slung in a Salter's swing or immobilized in plaster of Paris.

Treatment.—In cases where an attack of delirium tremens is considered imminent, either from the previous history of the patient, the tremulous state of his hands and tongue, or his sleeplessness, the best treatment to adopt is to support the strength by suitable, easily digested food, combined with free purging and, if need be, soporifics, such as chloral, bromide, paraldehyde, or morphia. Paraldehyde is perhaps the safest, whilst morphia must be administered cautiously; under such a regimen the symptoms usually soon disappear. In the acute maniacal attacks the patient must be fully controlled and guarded, but with as little manifestation of retraint as possible; failing other drugs, hyoscin in doses of $\frac{1}{200}$ to $\frac{1}{100}$ grain will sometimes succeed in quieting the patient, but must be used with great care, as it is a severe depressant. Nourishing food of a fluid type should be administered during the quiet intervals, and free purging is of course essential. The patient usually recovers from a first attack, but in the later ones may die of heart failure or exhaustion.

CHAPTER XI.

THE GENERAL TECHNIQUE OF OPERATIVE SURGERY.

No one who has been brought up in the modern school of antiseptic or aseptic surgery can have any idea of the horrors that were perpetrated under the name of surgery by our ancestors. Anæsthesia was unknown, and perhaps this was an advantage rather than otherwise, as it limited the number and the scope of operations. Patients had to be forcibly restrained during the procedure; hæmostatic forceps were not in existence, and the operating theatre was not the quietly decorous spot that it now is, but rather resembled the shambles. The wards were a hotbed of surgical fever, and erysipelas, pyæmia, and other manifestations of pyogenic infection led to an appalling post-operative death-rate. Hospital gangrene, wound phagedena, and other affections now happily extinct, were common enough, and not unfrequently wards had to be entirely closed in order to limit the ravages of such diseases. The almost synchronous discovery of anæsthesia and antisepsis has transformed surgery, and from being an art dangerous, barbarous, and almost repulsive, it has been changed into a scientific procedure, beautiful in its details and beneficent in its results. In this connection the names of Simpson, who fought the battle of anæsthesia, of Spencer Wells, who popularized the use of hæmostatic forceps, and of Lister, who first applied to surgery the principles that were being taught by Pasteur as to the microbic origin of disease, will ever stand out as three of the greatest benefactors of the human race.

The **Antiseptic** plan of treating wounds, as originally introduced by Lord Lister, is an outcome of the germ theory of putrefaction. It has for its object the prevention of bacterial development in wounds by the use of *chemical agents*, some of which are true germicides, capable of destroying the bacteria, whilst others merely prevent or inhibit their growth. Amongst the multifarious antiseptic agents which have been used, the most prominent are carbolic acid, corrosive sublimate, biniodide of mercury, iodine, iodoform, formalin, boric acid, salicylic acid, etc.

Carbolic Acid, the first antiseptic employed by Lister, has a direct germicidal action in strong solutions, and an inhibitory effect in weaker ones. The crystals, when heated with 10 per cent. of water, constitute an oily fluid known as pure or liquefied carbolic acid, which is a powerful though superficial caustic, and may be applied without much fear to infected living tissues —*e.g.*, to tuberculous sinuses or wounds—after scraping them, in order to destroy any portions of tuberculous material which may have escaped the spoon. Excess of the acid may be washed away with absolute alcohol, which quickly dissolves it. The liquid carbolic dissolves in water on the application of warmth, and the 1 in 20 and 1 in 40 solutions are those mainly employed; the former is an efficient and potent antiseptic, but must be used carefully on delicate skins. It is most important to ensure the complete solution of the acid, as otherwise globules of it may be deposited on the hands or in the wound, and may do much harm. Carbolic acid is frequently somewhat crude and impure, and many of the irritative and toxic phenomena are due to cresylic acid and other substances which should not be present. General absorption of this reagent leads to darkening of the urine, which may become olive-green or even black in colour, and this carboluria is often associated with giddiness, nausea, and vomiting, in bad cases progressing to a condition of collapse; diseased kidneys may be seriously affected. Weaker solutions are more readily absorbed than the liquefied or pure acid. It must be remembered that children and some adults are peculiarly susceptible to its action, and its application to large wounded surfaces, *e.g.*, burns, is inadvisable. On the other hand, its great affinity for all greasy and oily substances renders it a valuable antiseptic for emergency work, as it penetrates into the skin more readily than other agents. A solution in olive oil (1 in 20) or vaseline is sometimes used as a lubricant for catheters, etc., but is not very satisfactory.

Corrosive Sublimate is usually employed in solutions of 1 in 2,000, 1 in 1,000, or 1 in 500. Occasionally the last of these three solutions has 5 per cent. of carbolic acid added to it, constituting what is known as Lister's *strong mixture.* Sublimate solutions are inhibitory in action rather than germicidal, but are potent and reliable, especially in purifying the skin; when mixed with albuminous fluids, such as blood, an insoluble albuminate of mercury forms, which is ineffective as an antiseptic. They have less power of penetration than carbolic acid, and have less hardening or roughening influence on the skin. If, however, a dressing soaked in a sublimate solution (1 in 2,000) is kept for long in contact with the skin, it acts as a direct irritant, and may lead to an abundant formation of pustules, owing to the activity of the germs in the deeper parts of the cutis which have not been destroyed by the antiseptic. Instruments should not be placed in sublimate solutions, as, even if plated, they soon lose their bright appearance. It must be remembered that individuals very sensitive to the action of mercury may be salivated by this agent, and especially when used frequently for irrigating cavities to which a free exit is not provided. Symptoms of acute intestinal irritation, cramps, vomiting, and blood-stained diarrhœa, may also be caused.

Biniodide of Mercury is a potent antiseptic, which has been chiefly employed in the form of a 1 in 500 solution in 70 per cent. methylated spirit for the purification of the hands or of the skin of the patient. It is, of course, extremely toxic. A 1 in 2,000 aqueous solution is also employed for the hands, and is less harmful to instruments than the perchloride.

Boric or **Boracic Acid** is a mild and weak antiseptic, which may be utilized when stronger remedies might prove harmful—*e.g.*, in plastic operations and for infants. It is also useful when antiseptic fomentations are required in treating inflammatory phenomena, and in ophthalmic surgery.

Iodine is a most valuable antiseptic, and at the present time is largely employed to sterilize the skin before operations in alcoholic solutions, varying from 2 to 5 per cent. To be effective it is essential that the skin be previously freed from moisture or grease. In weaker solutions iodine is useful to irrigate suppurating cavities, or may be employed as a bath in which to immerse inflamed parts.

Iodoform is a yellow powder of characteristic and unpleasant odour, which probably acts by being decomposed in the tissues and slowly giving off iodine. Commercial iodoform is usually contaminated with a variety of germs; it is therefore wise to wash the iodoform before use in 1 in 20 carbolic lotion. Its chief value is in foul or tuberculous wounds, and, indeed, it seems to have a specific inhibitory action upon the development of the *B. tuberculosis*. It may be suspended in glycerine (10 per cent.), and after sterilization by immersing the vessel in which it is contained in boiling water for half an hour, this can be injected into tuberculous tissues, joints, or abscesses; or if open wounds exist, gauze soaked in this emulsion, as it is incorrectly termed, may be packed into them with advantage. Toxic effects of very variable type may follow from undue absorption of the drug. Gastro-intestinal disturbances, vomiting, diarrhœa, colic, etc., may be the chief symptoms, but delirium and collapse often supervene. There is always an abundance of iodine in the urine. Various substitutes have been proposed in order to avoid the unpleasant smell —*e.g.*, aristol, orthoform, etc.—but they are of doubtful value.

Chinosol is a yellow substance, harmless and free from toxic qualities; it is easily soluble in water, and possesses powerful antiseptic properties.

Lysol is another useful antiseptic derivative of coal-tar. It is freely soluble in water, and as a 2 per cent. solution may be used in syringing out cavities such as the vagina, external ear, etc. Its solution is somewhat soapy, and tends to cling to the tissues and prolong its action.

Permanganate of Potash, Sanitas, and **Peroxide of Hydrogen,** all act in the same way as oxidizing agents; they are necessarily unstable and cannot be utilized for dressings, and are therefore chiefly employed in the disinfection of cavities or wounds already contaminated. The most potent of these is peroxide of hydrogen, which is sold as a fluid capable of setting free 10 to 20 times its volume of nascent oxygen. It is quite unirritating, and may be poured directly into an infected wound, or even into the peritoneal cavity; forthwith it commences to effervesce, liberating its oxygen, and forming a frothy foam, which is likely to bring to the surface any loose sloughs or foreign bodies. Its use is particularly indicated in the treatment of dirty ulcers, carbuncles, sloughy abscess cavities, and the like. Sanitas and permanganate of potash are used in solutions of varying strength, and act more slowly; the latter has the disadvantage of staining the tissues with which it is brought in contact.

Formalin is a powerful antiseptic, and consists of a 40 per cent. aqueous solution of formic aldehyde. It is decidedly toxic, even in a 1 per cent. solution. It blackens steel instruments, gives off an irritating vapour, and hardens the skin to an unpleasant degree.

The **Aseptic Method** of treating wounds consists in the elimination of chemical antiseptics as far as possible, and the substitution of heat, dry or moist, as a sterilizing agent. Every efficient antiseptic is more or less toxic and irritating, and there can be no question that, from an ideal standpoint, the less they are introduced into wounds, the better. No more satisfactory germicide can be imagined than heat, in the form either of boiling water or of steam under pressure, and it is claimed that if everything brought in contact with the wound is aseptic, then no antiseptics need be employed. Dressings, swabs, towels, aprons or coats, and caps, are sterilized in drums or kettles by means of steam at ordinary pressure, or by superheated steam at high pressure. The latter, of course, is the more satisfactory, owing to its greater penetrative power, but the former can be effective if the drums are so constructed as to permit a free passage of steam through the articles to be sterilized, and if the latter are packed loosely and not tightly. The drum is first lined with a layer of lint or gauze, and a similar covering must be placed over the contents beneath the lid. A sliding shutter, or some suitable contrivance, allows the entrance of steam into the drum. When the drum is removed from the sterilizer, this shutter is closed, and the contents may be expected to remain sterile for a day or two, but not for long unless hermetically sealed. For small establishments a Schimmelbusch's low-pressure dressing sterilizer or a small high-pressure (from 5 to 15 pounds) steam sterilizer answers excellently; but for large hospitals an extensive and expensive plant must be installed, and probably some variety of the Washington-Lyon sterilizer is the best. For private practice supplies of effectively sterilized articles in hermetically sealed tins or drums can now be obtained from many instrument makers and chemists.

Of course, there are two elements in an operation which can never be sterilized apart from chemical antiseptics—viz., the skin of the patient and the surgeon's and assistants' hands—and thus the most complete aseptic precautions can never entirely eliminate chemical agents. Moreover, it must not be forgotten that the air itself holds numberless germs which cannot be excluded from the wound, and that such germs are more numerous in crowded cities and in places where sick people are likely to congregate. To obviate this, most elaborate precautions have often been taken in order to filter the air admitted to the operating theatre, and also as to the cleanliness and dress of the surgeon and his assistants. Unsterilized persons, and therefore students, are frequently banished from the operating theatre, or placed behind a glass screen, as every additional onlooker must increase the risk in purely aseptic conditions. Then, too, the surgeon ought to be able to rely on assistants and nurses who are not changing every six or twelve months, as there is no second line of defence in the presence of antiseptics to make good errors in technique. Moreover, away from hospital, surgeons are not always able to command aseptic conditions, but may have to operate in very unsuitable surroundings. Hence, in a large teaching hospital, devoted to the training of students and nurses (and such, we believe, can only be carried out effectively by their active participation in the work), it is quite a question whether it is desirable to maintain a purely aseptic clinique.

The *actual details of operative technique* vary somewhat with different surgeons, but the main principles which govern modern operative surgery are much the same in all, and the following sketch of the preparations required and of the routine usually practised in undertaking an operation may be considered more or less typical of modern methods:

1. **The Operating Theatre or Room.**—The arrangement of this necessarily depends upon considerations of space and finance. It should not be unnecessarily large, and the old-fashioned theatre with tiers of seats overlooking the central area is not desirable. Onlookers should have a low gallery provided for them, but little raised above the floor-space and shut off from it not merely by a rail, but by an effective barrier breast-high. It may with advantage be placed between the operating area and the source of light, but clear of the window, or to one side, and should be entered by a separate passage and not through the theatre. A north light is desirable,

and it should come, not from the top, but from the side, in the form of what is known as a 'studio light.' The walls should be free from ledges on which dust may accumulate, and lined with white tiles or glazed bricks, or, better still, present a smooth surface painted with white enamel, which can be washed down with a hose; of course all corners should be rounded. The floor must be impermeable, and slope towards an open channel on one side of the theatre, so as to allow of suitable flushing with a hose. All shelves must be made of glass, but the fewer fixtures in the actual theatre the better. The heating arrangements should be such that the temperature can be raised, if necessary, to 75° or 80° F. Attached to the theatre should be a suitable series of smaller rooms for the anæsthetist, for sterilizing purposes, etc.

In a private house the room must, if possible, be carefully prepared beforehand. The carpet should be taken up and curtains removed. The walls should be wiped over with an antiseptic solution, and the floor thoroughly scrubbed; all unnecessary furniture is removed. Should the operation be an emergency one, without time for such complete preparation, it is often wiser to leave things alone, and not stir up dust and dirt by a hurried attempt to make the place look a little better than it really is. A suitable supply of hot and cold boiled water must be secured beforehand, and basins and dishes, etc., should, if possible, be previously boiled.

2. The **Surgeon** must remember the very grave responsibility that rests upon him in undertaking many of the modern operations, and he must be willing and ready to submit himself to the strictest régime. In a general hospital the surgeon will probably lay aside his outdoor clothes and boots, and don an operating suit consisting of a soft white shirt, white 'drill' trousers, and a pair of clean shoes; he will then proceed to purify his hands and arms, and finally puts on a sterilized gown reaching to the wrists, a sterilized cap and mask covering the whole face except the eyes, and sterilized gloves reaching over the lower end of the sleeves. The *assistants* will be similarly prepared. Where such a complete change is impossible, the shirt-sleeves must be turned up well above the elbows, and other preparations made as before. During the operation unnecessary talking is forbidden, and if one has to cough or sneeze the head is turned completely aside.

Similar rules hold good in regard to the *nurses*, whose arms should be bare to the elbows, and who should wear sterilized coats; the hair must be covered by a sterilized cap, even if a mask is not considered necessary.

The **hands** and **arms** must be as thoroughly and effectively purified as if no aseptic coverings were available. They are scrubbed thoroughly with soft or ether soap and hot water; the nails are cut if need be, special attention being directed to the semilunar folds of skin at the base, where infected material is apt to collect. For this purpose a purified nail-brush is employed with advantage, and if a running stream of hot water can be obtained, so much the better.

The hands and arms are then bathed in an efficient antiseptic solution—*e.g.*, a 1 in 500 solution of iodide of mercury in 70 per cent. methylated spirit for one minute, and then in a 1 in 2,000 sublimate solution. The hands and arms, once purified, should not be dried except on a sterilized towel. It is possible that complete sterilization of the hands is not effected in this way, but the surgeon must always aim at obtaining it. On several occasions when our hands and those of our assistants were tested bacteriologically after this method of preparation, they were found to be sterile, even scrapings from beneath the nails giving no reaction.

The majority of surgeons nowadays use thin **rubber gloves,** which can be sterilized by dry heat, or boiled in water without soda; if dry, they can be easily slipped on after dusting them inside with a sterilized powder, such as boracic acid or French chalk; the hands must, of course, be dried previously. Boiled gloves are best put on by everting them, and thoroughly anointing the interior with sterilized glycerine; or the hand may be immersed in methylated spirit, and the gloves then slip on easily. They are made so thin that the delicacy of touch is but little impaired, especially when the use of such gloves has become habitual. They can be slightly roughened on the exterior, so that even slippery structures, such as intestine, can be held. They should fit accurately and extend well above the wrist. Care must of course be taken to ensure that the fingers of the gloves are not punctured. **Cotton gloves** are used by some surgeons, and several pairs may be required during a single operation; they do not appear to be so satisfactory as the former.

Assistants and nurses taking any part in the operation should also wear gloves, especially if the handling and wringing out of swabs is entrusted to them.

Much of the success of an operative clinique depends upon the methodical and effective organization of the same. It is desirable that all unnecessary hands should be eliminated, and therefore everything likely to be needed should be laid out within reach of the surgeon and his assistants on suitable side-tables, so that they may be able to take up instruments, ligatures, and sutures, etc., without being touched by others.

3. **Instruments** are sterilized by boiling in a weak solution of bicarbonate of soda (1 per cent.) for five or ten minutes, or more if they have been previously used for a dirty case. To prevent them from rusting, they should be carefully plated, and the water ought to boil for some minutes before they are immersed, in order that the suspended air may be driven off. After boiling they may be laid out on a sterilized dry towel and covered over with a similar towel till they are required, or kept in a weak antiseptic solution—*e.g.*, carbolic lotion, 1 in 60. Mercurial solutions should be avoided, as they spoil the instruments. If during an operation an instrument which has not been previously sterilized is required, it may be quickly purified by immersing it for half a minute in liquefied carbolic acid, the excess of which is removed by washing thoroughly in

alcohol or hot sterilized water. The same process or re-boiling must be adopted for any instrument which falls on the floor or becomes otherwise soiled. Special care must be directed towards the forceps, to see that the serrations are freed from dried blood-clot and other dirt. Hæmostatic forceps should be opened before boiling.

4. **Swabs** have now so completely taken the place of sponges in surgery that it is unnecessary to consider the preparation of the latter. Swabs are made of absorbent wool wrapped in a single square layer of gauze the corners of which are tied across and tucked in; or they may be composed of gauze alone, folded over, and perhaps stitched so as to leave no free edge which may fray out; or they may be formed of larger squares of absorbent material, such as Gamgee tissue. A sufficiency of these, suited in size and shape to the requirements of the case, is provided before the operation. They are sterilized in a suitable autoclave or sterilizer, and kept in the drum until required, when they are removed by sterile hands or instruments to a sterile receptacle, being used dry or after immersion in lotion. In case of need, where a sterilizer is not available, they may be boiled and then kept either in boiled water, covered over till required with a sterilized cloth, or in an antiseptic solution; or may be dried in an oven after being enclosed in a suitable cloth.

Cloths and gauze strips for abdominal operations are prepared in a similar manner. In these cases a careful record must be kept of the numbers used, so that all may be accounted for afterwards; indeed, it is wise always to have swabs, etc., done up in packets or bags containing a known number, such as a dozen.

5. The **Ligatures** and **Sutures** demand very thorough purification, which varies with the material used. Silkworm-gut, horsehair, and silver wire, which do not imbibe fluids or become absorbed, merely require to be boiled, but silk and catgut need much more care if stitch suppuration is to be avoided. **Silk** must be boiled for twenty or thirty minutes, and should be wound loosely on reels or winders, so that the deeper strands may become sterile as well as the superficial. It may be used at once or after being kept in spirit or in some antiseptic lotion, such as a solution of sublimate (1 in 1,000), for a week or until required, so that its strands may become well impregnated with the salt. An important precaution in the use of silk is to soak it in sterilized water before use, especially if it has been kept in spirit; the object of this is to protect the tissues from the caustic action of the latter, and thereby hinder stitch suppuration. Moreover, silk should *never* be *used with ungloved hands;* the strands cut through the epidermis and become contaminated by germs lying in the deeper layers of the skin, and stitch suppuration may result.

Catgut is still more difficult to purify, inasmuch as boiling in water is out of the question. Lord Lister claimed that catgut, prepared according to his directions (p. 290), remains actively antiseptic for an indefinite period, and that it suffices before use to immerse it in a 1 in 20 solution of carbolic acid for a quarter of an hour. The majority of surgeons, however, prefer to sterilize it before use, and especially so if they used non-chromicized gut or catgut which has been hardened in a 5 per cent. solution of formalin for twenty-four hours. Many different processes have been recommended, but perhaps the simplest and most effective is that known as the 'iodine' method. The catgut is wound loosely on a glass spool or winder, and immersed in a solution containing iodine, 1 part; iodide of potassium, 1 part; and distilled water, 100 parts. It is kept thus in the dark for seven to ten days, and then removed and kept dry, wrapped in sterile gauze. Before use it is placed for a few minutes in spirit (rectified or methylated), so as to dissolve out a little of the excess of iodine present. Catgut so prepared is not only aseptic, but also actively antiseptic, and rarely causes trouble in the tissues (except, perhaps, in delicate children). An extensive experience of this material for some years has proved its reliability and value. Various instrument-makers provide sterilized catgut in sealed glass tubes, which can usually be trusted.

6. The **skin of the patient** is carefully prepared before operation, the length of such treatment depending on the cleanliness or not of the part and the urgency of the case. The skin is first shaved, if necessary, and washed with soft or ether soap andhot sublimate lotion (1 in 2,000); acetone or turpentine may be used to remove grease and excessive dirt. It is then flushed with biniodide of mercury in spirit (1 in 500), or with carbolic lotion (1 in 20), and afterwards the stronger antiseptic is washed away with a weaker solution either of carbolic acid or sublimate. The part is finally wrapped up in an antiseptic compress—*i.e.*, of gauze or lint, soaked in 1 in 40 carbolic or 1 in 2,000 sublimate solution. At the time of operation the same process may be repeated. It must not be forgotten that a very vigorous use of carbolic acid may be followed by local irritation, as well as by its absorption into the blood-stream, especially in protracted operations and in children. Care must also be taken that the patient does not lie in a pool of antiseptic lotion which has run down during the washing and collected under the sacrum; many a bad antiseptic burn has resulted therefrom. Again, not only does the quality of the skin vary in different individuals (as may be illustrated by contrasting that of a coal-heaver, who possibly bathes once a year, with that of a child or lady, which is soft, clean, and delicate), but it also differs in various regions of the body, and hence the process of purification must be modified according to the character and thickness of the integument. Any part where dirt may accumulate demands scrupulous attention—*e.g.*, the umbilicus, external ear, toes, or corona glandis in persons with long foreskins. A word of warning is also needed as to the too vigorous use of a nail-brush leading to a traumatic dermatitis, or even waking up into activity germs which otherwise would have lain dormant in the deeper layers of the uninjured skin. It may be again mentioned that in cases of emergency it is wiser to trust in carbolic lotion than in sublimate, as the former unites freely with the grease of the skin, and hence penetrates more deeply.

This method of preparing the patient has, however, been largely displaced by the discovery of the penetrating antiseptic properties of *iodine*, to which Mr. Waterhouse drew attention (*Lancet*, April 16, 1910). The all-essential element in the use of this agent is that the skin to which it is applied must be quite dry; moisture causes the cells of the prickle-celled layer to swell up, and hinders the action. It may therefore be employed directly in casualty work to a dirty skin without washing. In operative work the part to be purified should be shaved and washed twelve hours before, and wrapped in a sterilized towel; the iodine is painted over two hours before operation, and the sterile covering replaced; and finally on the operating table the parts are painted once again. The solution employed should be one containing 2 or 2·5 per cent. of iodine in *rectified*, not methylated, spirit; the latter causes intolerable irritation of the eyes The iodine method is quite reliable, if the precautions noted above are taken, but occasionally it causes some irritation of delicate and sensitive skins.

7. The **area of operation** is surrounded by mackintoshes, which should always be purified or sterilized, and these in turn are covered with dry sterilized towels, fixed to the skin by suitable towel-clips. Failing dry sterilization, the towels may be boiled, and subsequently dried by baking in an oven, or soaked in an antiseptic solution. During an operation irrigation or flushing is unnecessary, unless the proceedings are prolonged, and then hot sterilized salt solution should be employed for the purpose; but a final flushing with carbolic lotion (1 in 40) or with sublimate (1 in 2,000) is sometimes useful, especially when operating under conditions which are not ideal as to surroundings and technique. The objection to such flushing is that the lotion is more or less of an irritant, and determines a certain amount of subsequent oozing and effusion, which will necessitate drainage. More particularly, when dealing with the peritoneal cavity or interior of a joint, the less one employs antiseptics the better; they lead to a desquamation of the delicate endothelial lining which it is so important to maintain intact.

8. Before closing the wound absolute **hæmostasis** should be secured, and then the wound may usually be stitched up completely and without drainage. It is important to build up again the divided tissues of the part by suitable buried sutures, so as not only to secure more perfect apposition, but also to obliterate ‘ dead spaces ’ in which blood-clot or effusion may collect. In this way wounds through fleshy and vascular structures—*e.g.*, an amputation through the thigh—may sometimes be completely closed up without drainage. On the other hand, where accurate apposition of tissues and obliteration of cavities cannot be obtained, as after clearing out the axilla, and where some amount of oozing may be expected, it is advisable to insert a suitable drainage-tube, and stitch it flush with the surface. It is removed at the end of forty-eight hours at most; in such cases the removal of the discharge and the changing of the soaked and perhaps stiffened dressings add materially to the comfort of the patient.

When the operation has been completed, the skin around is cleansed with lotion, but *only after a piece of dressing has been placed as a protection over the wound.* This cleansing should always be accomplished by wiping peripherally away from the wound, and any swab utilized for this purpose should not again be allowed to touch it.

9. Finally, a carefully arranged **Dressing** is applied, and the part bandaged and placed at rest on a splint or in a sling, if such is indicated by the requirements of the case; absolute rest and quiet are essential if rapid healing is to be obtained.

Lord Lister pointed out some years back that the main essentials of a good dressing consisted in its containing some trustworthy antiseptic ingredient; in this agent being so stored up that it cannot be dissipated before the next dressing; in its being entirely unirritating; and in the capacity of the fabric readily to absorb blood or serum that may ooze from the wound. The original antiseptic dressings—viz., the carbolic and eucalyptus gauzes, and even the alembroth gauze and wool—failed to fulfil these requirements; but in the double cyanide of mercury and zinc gauze we have a material which is to all intents and purposes perfect. It should be soaked for some hours in carbolic lotion (1 in 20), and applied to the wound without fear after wringing it out of a 1 in 40 solution; or it may be sterilized and applied dry. A sufficiency of this is employed so as to cover in a wide margin of skin all round the wound, and, finally, over all a liberal covering of sterilized or antiseptic wool, so as to diffuse the pressure, which is applied by means of careful bandaging. The best material for bandages is butter-cloth, since it is light and adapts itself easily to the outlines of the part. Other dressings, such as boric lint, iodoform gauze, etc., are occasionally employed, but they are not so satisfactory for general use as the cyanide gauze.

Many surgeons employ simple sterilized gauze without any antiseptic ingredients, and where complete asepsis has been maintained and no great amount of discharge is expected, this will suffice admirably. An antiseptic dressing is, however, an extra safeguard that may be wisely adopted, and especially in cases where a good deal of post-operative oozing is likely to occur. Thus in a case of excision of the astragalus, where by an oversight the dressing, though badly soiled, had been left untouched for a week, the bandage and aseptic wool soaked with a blood-stained discharge stank; but on removing them and taking off the underlying cyanide gauze, the fœtor gradually diminished, and the wound was found to be uninfected, and ran an ordinary course to repair. The bacteria, which were attacking the parts from without, were unable to penetrate the cyanide gauze, which probably saved the boy from losing his foot.

10. **After-Treatment.**—If no drainage-tube has been employed, and the dressing is not soaked through, it may be left untouched for seven or eight days, at the conclusion of which period it is removed, the stitches are taken out, and in all probability the wound will be completely healed. When a drainage-tube has been inserted, it is usual to take it out at the end of twenty-four or forty-eight hours;

there is no advantage in retaining it longer, since it is only required for the removal of the sero-sanguineous fluid which exudes immediately after the operation. Should this early discharge be very abundant and soak through the dressings, there is no actual need to remove them and re-dress during the first twenty-four hours, if cyanide gauze has been employed; all that should be done is to damp the stained external bandages with 1 in 20 carbolic lotion, and then pack on some more gauze or wool. This may even, if necessary, be be repeated a second time. But where merely sterile gauze has been used, it is wise to redress the wound completely.

The **after-dressings** of the wound need to be conducted with the same precautions as to asepsis of hands, instruments, etc., as the original operation, and not a few instances of infection at the first dressing occur. It is essential that everything likely to be required should be prepared before the dressings are removed, so that exposure to the air may last as short a time as possible. If the first dressing is undertaken after twenty-four or forty-eight hours, and all is going on satisfactorily, the tube is removed, and the wound redressed in exactly the same way as formerly, though probably much less gauze will be required. If the case is left for eight days, the stitches can probably be taken out, and the skin incision will then be found united. A small dressing of cyanide gauze is applied, fitting closely to the scar, and sealed down with flexile collodion, which will not only prevent the gauze from slipping, but will also by its contraction serve to steady the parts. This should be covered with wool and a bandage, so as to support the parts, and may be finally removed at the end of another week.

An **open method** of treating certain operation wounds has been recently adopted with considerable advantage. Absolute hæmostasis is the first essential, and the wound must be completely closed without drainage. It is carefully dried and painted over with 2 per cent. solution of iodine in spirit. A sterilized towel may be placed around the part for the first twenty-four hours; but this may be discarded afterwards, and the wound is left uncovered, and merely painted with the iodine solution daily. In the case of children some arrangement of the bed-clothes must be devised to keep their fingers away from the part. Hernia operations and similar wounds do excellently under this régime.

CHAPTER XII.

HÆMORRHAGE.

By the term *hæmorrhage* is meant any escape of blood from the vessels, whether insignificant and immediately arrested by natural means, or more excessive and requiring treatment to prevent its continuance. Although most commonly due to some injury, whether subcutaneous or inflicted through the skin, it may be predisposed to by weakness of the vascular tissues, especially if associated with increased blood-pressure. Certain diseases, such as purpura and scurvy, are characterized by a tendency to bleeding, and there is one congenital condition, hæmophilia, in which it is difficult to stop the flow of blood when started.

The **character** of the bleeding differs according to the vessel from which the blood escapes. **Arterial Hæmorrhage** consists in a flow of bright red blood, which escapes at first *per saltum—i.e.*, in jets synchronous with the heart's beat, and may be derived, not only from the proximal, but also from the distal end of the divided vessel, if the collateral circulation is sufficiently abundant. If, however, it is derived from a deep artery, the blood may well up from the depths of the wound and not escape in gushes. In **Venous Hæmorrhage** the flow is usually continuous, and the blood of a dark red or almost black colour. If, however, a large vein is wounded, such as the internal jugular, the blood may escape with a very definite spurt, owing to respiratory or other influences. **Capillary Hæmorrhage** is marked by general oozing from a raw surface, the blood trickling down into a wound, if present, and filling it from below upwards. By **Extravasation of Blood** is meant the pouring out of blood from a wounded vessel or vessels into the lax areolar planes immediately adjacent, which become swollen and boggy. The usual constitutional signs may be manifested as a result of such extravasation, and, indeed, fatal hæmorrhage may occur in this way without any escape upon the surface of the body. Subcutaneous or submucous hæmorrhage is also met with in the form of small localized **petechiæ,** arising from injuries, or from changes in the blood or vessel walls (as in purpura, scurvy, and septicæmia). **Epistaxis** is the term given to bleeding from the nose. By **Hæmatemesis** is meant the vomiting of blood; it may either have been swallowed, as in some cases of fractured base of the skull, where the pharyngeal mucous membrane has been torn, or it may have originated from the upper part of the intestinal tract. If it has remained in the stomach any length of time, the blood becomes curdled and brownish in colour, somewhat resembling coffee-grounds, from the action of the gastric juice upon it. When gastric hæmorrhage is more active, the blood is bright red in colour, and may be vomited in the form of large clots **Hæmoptysis** is the title given to the escape of blood from the air passages, whether it results from injury or disease. The characters vary with the quantity lost; in the milder cases it is usually bright red and frothy from admixture with air; in graver cases, when larger vessels are involved, the blood may escape unaltered, and be so abundant as to asphyxiate the patient. **Hæmaturia** (*q.v.*) is a condition in which blood is passed in the urine. By **Melæna** is meant the passage of dark tarry blood with the fæces; it is always an evidence of disease or injury of the intestinal canal sufficiently far from the anus to allow the blood to become altered in character by the action of the intestinal juices. Blood derived from the rectal mucous membrane usually retains its bright red colour.

Constitutional Effects.—If the hæmorrhage is severe, as from division of a large artery, death results from syncope. The surface of the body becomes cold, clammy, and pale; the lips, ears, and eyelids are livid; the patient gasps, his respirations become quick and sighing, and death ensues after perhaps a few convulsive twitches of the limbs.

If the hæmorrhage is not so great as to kill immediately, the patient faints, and on recovery is in a condition of severe collapse and weakness, which continues for some time; he is also liable to recurrent attacks of syncope, especially if the bleeding recurs.

If the hæmorrhage is *concealed* and of moderate severity, as from ulceration of the stomach or duodenum, or by slipping of a ligature after an abdominal operation, the patient rapidly becomes profoundly anæmic, and his face shrunken and drawn as a result of the dehydration of the tissues of the cheeks. The organs of the body generally suffer from want of oxygen, and hence the patient feels as if he were being suffocated, and is extremely restless, tossing about in bed, and clamouring for open windows and more air (*air-hunger*). Any sudden exertion, or even sometimes the attempt to sit up, is followed by a sensation of faintness or actual syncope; noises are heard in the ears, the sight becomes dim, or is even temporarily lost (amblyopia), and severe headache may be complained of, all arising from cerebral anæmia. The pulse often becomes what is known as *hæmorrhagic* in character—*i.e.*, frequent—and compressible, but collapsing entirely between the beats, and markedly dicrotic. These peculiar features are due to the sudden passage of a small amount of blood through a vessel which is practically empty. From the defective *vis a tergo*, œdema of the extremities may result

During the continuance of hæmorrhage the blood-pressure necessarily falls; but unless the loss is great, it quickly rises again to the normal after the bleeding has ceased. This rise in blood-pressure is partly due to a diminution in the size of the vascular area, owing to vasomotor contraction of the peripheral arterioles and of the splanchnic area, but is also caused by an increased flow of lymph into the circulation. For the changes that occur in the blood as a result of hæmorrhage, see p. 58. The hæmoglobin is gradually restored, and an increase of 1 per cent. daily is about the normal rate (Emery).

Children and elderly people alike bear the loss of blood badly; but whereas children rapidly recover from the immediate effects, elderly people do not.

General Treatment.—When the loss of blood has been severe, the patient must be kept quiet with the head low, whether syncope is present or not. The foot of the bed or couch should be placed on blocks or on chairs, so as to assist in the maintenance of the circulation to the medullary centres. *Stimulants* may be necessary to maintain the heart's action, but *should never be given until the bleeding has been effectively controlled*, as otherwise they may increase or re-start it. If death appears to be imminent, the arms and legs should be bandaged, or the abdominal aorta compressed, in order to confine the blood as much as possible to the head and trunk.

'No patient should be allowed to die of hæmorrhage.' Such was the dictum of the late Mr. Wooldridge, of Guy's Hospital, based on a knowledge of the value of transfusion and infusion. By **Transfusion** is meant the transference of blood from one individual to another; it has now, however, been recognised that the *success* of this proceeding *depends on* the introduction of a sufficient *quantity* of fluid as a temporary substitute for the blood which has been lost, *rather than* on its *quality*; for it has been proved that the transfused blood of another person is rapidly destroyed and eliminated. Hence transfusion has now been replaced by the **Infusion** of some bland fluid, isotonic with blood-plasma, into the vessels, and by this means greatly improved results have been obtained. The apparatus required is a metal or glass cannula, the end of which is bulbous, blunt, and bevelled, which can be inserted into a vein, and connected by means of a rubber tube with a reservoir containing the fluid (Fig. 89). A vein—*e.g.*, the median basilic or internal saphena—should be exposed, tied below, and opened by a longitudinal or oblique incision; the cannula, filled with lotion so as to exclude air, is then inserted, and a ligature placed round the vessel, so that on withdrawal it can be tightened. The amount injected varies with the circumstances and the effects produced, but, to be efficacious, some 2 or 3 *pints* are usually needed; this may be repeated, if necessary, but rectal infusion will often suffice in the later stages.

As to the material, a warm saline solution is the best, consisting of a drachm of chloride of soda to a pint of sterilized water (or about 0·6 per cent.), at a temperature of 105° to 110° F. Tabloids or tablets of the dried salt are dissolved in a small quantity of boiling water, and this is then diluted to the required bulk and temperature. Of course, the apparatus is carefully sterilized by boiling, and no air must be admitted. The injection is made slowly, so that the solution may be mixed gradually with the blood. It has been found by experiment that after an infusion following hæmorrhage the specific gravity of the blood is only lowered for a very short period, and rapidly rises to a normal level, or may even be raised above the normal. This suggests that the increased amount of fluid is absorbed into the tissues, and explains why it is sometimes necessary to repeat the injection more than once.

In the later stages of recovery from hæmorrhage and in cases of shock the introduction of warm saline solution into the rectum (*proctoclysis*), or through an exploring needle connected with a tube and funnel into the loose connective tissues of the buttock, abdomen, or submammary region (*hypodermoclysis*), is exceedingly valuable. In the latter case the funnel or receiver must be held at some height (5 or 6 feet), in order to gain sufficient pressure. and by this means a pint or more may be slowly injected; a carefully sterilized syringe and a large needle may be employed for the same purpose. During the injection the part should be gently rubbed so as to distribute the fluid. For method of proctoclysis, see Chapter XXXV.).

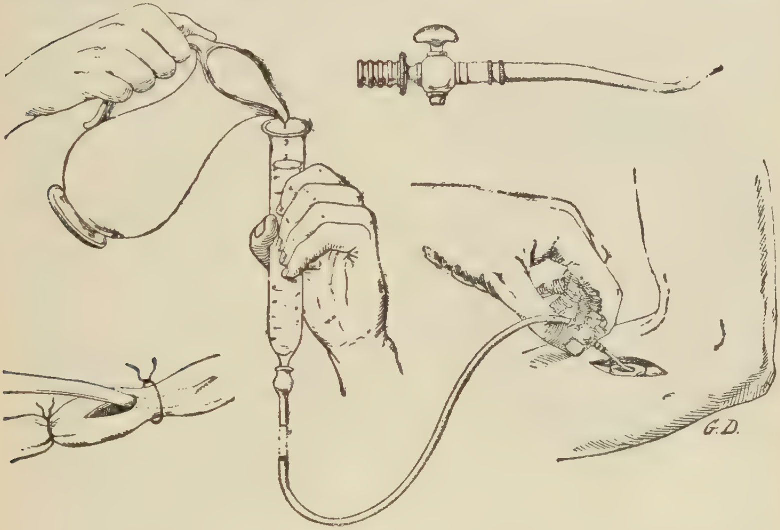

FIG. 89.—INFUSION INTO VEIN OF FOREARM.

Above, a useful form of metal cannula is represented; below, the arrangement of the ligatures on the vein.

Natural Arrest of Hæmorrhage.

The process is much the same for arteries, veins, or capillaries; but since the arrest of arterial hæmorrhage has been more thoroughly investigated, and is the most important, we shall deal mainly with it.

The **Temporary** arrest of arterial hæmorrhage is brought about by three principal factors:

(1) The **coagulation of the blood,** which occurs in and around the vessel, and without which death would ensue from the merest scratch. The coagulability of the blood varies in different subjects, and is influenced by various conditions—*e.g.*, the amount of calcium salts present. In hæmophilia the blood coagulates with difficulty, and therefore hæmorrhage is always a serious phenomenon in this affection. Loss of blood increases the coagulability to a certain degree.

(2) **Diminution in the force of the heart's action** always follows hæmorrhage from anæmia of the cerebral centres—a beneficent provision whereby coagulation is facilitated and the flow of blood checked. *Until the vessel has been efficiently secured, stimulants should therefore be carefully avoided.*

(3) **Changes in and around the vessel** play a most important part in completing the process. They consist in the **retraction** of the artery within its sheath by reason of its inherent longitudinal elasticity; if, however, it is only divided partially (or, as it is called, 'button-holed'), this condition cannot obtain, and the hæmorrhage is more likely to continue. As a result of this retraction, the rough and uneven inner lining of the sheath is exposed, and upon this the blood coagulates as it flows, thus gradually producing what is known as the **external coagulum.** At the same time the transverse muscular and elastic fibres in the vessel wall cause **contraction** of the open mouth, and thus the external coagulum is able to increase in size by fresh deposits of fibrin, until at last its resistance is too great for the diminished cardiac impulse to overcome, and the sheath is filled with clot, which extends to the divided mouth of the vessel. From this an **internal** coagulum next develops, which sometimes extends upwards as far the nearest patent branch. Thus the hæmorrhage is arrested for the time being, and preparation made for—

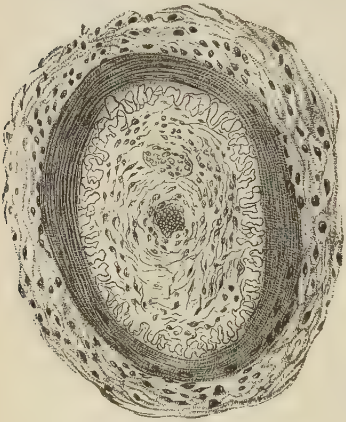

FIG. 90.—ORGANIZED THROMBUS IN VESSEL, SHOWING THE NEWLY-FORMED CONNECTIVE TISSUE OCCUPYING THE LUMEN OF THE VESSEL, AND VASCULARIZED FROM THE VASA VASORUM. (TILLMANNS.)

Two giant cells are seen in the centre.

The **Permanent** closure of the wound in the artery, which merely consists in a modification of the general process of repair. The vessel wall contracts upon the internal coagulum, with which, however, it does not unite, except at and near its base. As a result of the injury, a simple plastic arteritis is set up, evidenced by a hyperæmic condition of the vessel wall and its infiltration with leucocytes, which also invade the coagulum and cause its base to become decolorized. The leucocytes break up the clot, traversing the natural lines of cleavage which result from its contraction, and gradually remove it, a few giant cells occasionally assisting in this process (Fig. 90). The tunica intima proliferates concurrently, causing a secondary infiltration with the larger fibroblastic cells in that part of the thrombus which is adherent to the vessel wall (Fig. 91); whilst a growth of granulations springs up in those parts of the vessel wall where the apex of the clot lies free and unadherent, new vessels being derived from the vasa vasorum. The free conical extremity of the clot contracts, and is gradually removed, partly by the activity of leucocytes which infiltrate it from the base, partly by the erosive action of the surrounding granulation tissue. A similar set of changes occurs at the distal side of the ligature in an artery tied in its continuity. The ligature itself may be infiltrated by leucocytes, and replaced by granulation tissue, or may be encapsuled. A rod of granulation tissue is thus developed, blocking the vessel, and this, by the usual process of repair, is transformed into a firm cicatricial cord in the course of a few months (Fig. 90). It must be clearly understood, however, that the presence of a coagulum is by no means essential to the obliteration of an artery. Thus, if the walls are merely brought into close and accurate apposition by a ligature without dividing the inner or middle coats, a proliferative endarteritis without any clot formation results which is quite sufficient for the occlusion of the vessel.

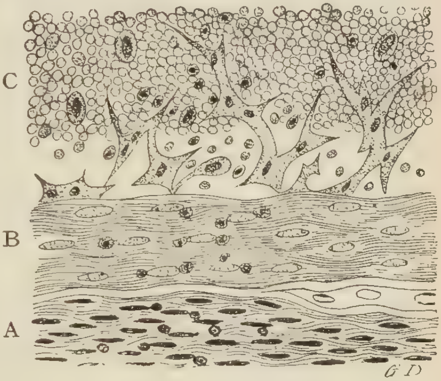

FIG. 91.—DIAGRAM OF EARLY STAGE OF ORGANIZATION OF THROMBUS, TO SHOW THE INFILTRATION OF THE CLOT WITH LEUCOCYTES AND CONNECTIVE-TISSUE CELLS DERIVED FROM THE ENDOTHELIUM. (TILLMANNS.)

A, Tunica media; B, tunica intima, undergoing proliferative changes, and therefore thickened; C, blood-clot lying in lumen of vessel, becoming infiltrated with leucocytes (small dark cells) and larger fibroblasts derived from the endothelium.

The arrest of hæmorrhage from veins and capillaries is more easily accomplished, the collapse of the walls, and the absence of blood-pressure facilitating the process. The later steps are similar to those occurring in an artery, except that there is but little internal coagulum.

Surgical Treatment of Hæmorrhage.

Many different methods are needed, under varying circumstances, for the effective arrest of hæmorrhage. It may be laid down as a preliminary axiom, that *digital pressure over the bleeding-point will always check temporarily the most furious outburst,* whilst means for its permanent stoppage are being arranged.

Where the bleeding is general and does not come from any one particular vessel, the following measures can be utilized:

1. **Position.**—When the bleeding is from one of the extremities, especially the lower, elevation by emptying the veins will determine a reflex contraction of the arteries, and thereby assist hæmostasis.

2. **Cold** may be employed in the form of ice, cold water, or lotion, or simple exposure to the air, all clots, swabs, pledgets, etc., being removed for this purpose; it must, however, be remembered that ice and unsterilized water may convey infective germs. Such treatment is of most value for general oozing from vascular structures or into cavities, such as the mouth, vagina, or rectum.

3. **Hot Water** (130° to 160° F.) is a powerful hæmostatic. It is supposed to act by stimulating the involuntary muscular fibres of the vessel wall; but probably the coagulation of the albumin of the blood is an important factor, as unless the water is hot enough to blanch the surface of the wound, the bleeding is not stayed, but rather encouraged.

4. **Cauterization** is but little used as a hæmostatic, except for the bloodless removal of vascular tumours, either as a galvano-cautery, a Pacquelin's knife, or, in the case of piles, as the ordinary clamp and cautery. Occasionally, however, it is used for bleeding in tissues which are infiltrated and thickened by chronic inflammation so that a ligature cannot be applied. It must be remembered that in order to seal effectually the mouths of the vessels, the cautery must be at a dull red or black heat ; a bright redhot iron cuts through a vessel as cleanly as a knife, and does not stop the hæmorrhage.

5. **Chemical Agents** may be used to assist in checking hæmorrhage from spongy tissues, or from deep cavities or organs, and act in diverse manners. (*a*) They may act locally as *styptics* by causing direct coagulation of the blood—*e.g.*, liq. ferri perchloridi or pernitratis, tannic or gallic acids, alum, nitrate of silver, styptic colloid, etc. In employing these, the surface of the wound must be cleansed and dried as far as possible, and the styptic then applied on lint or gauze. Unfortunately, the more active, such as liq. ferri perchloridi, are actively caustic, and may cause sloughing; it is seldom that such a drug is employed. (*b*) They may increase the coagulability of the blood, and of these lactate of calcium is the most effective. It is usually administered *per rectum* in a small enema containing 15 grains, and this may be repeated two or three times in a day. The use of this drug before operations which are expected to be very sanguinary has been most satisfactory in many

cases. (*c*) They may be effective as *vaso-constrictors*, and of these the chief is adrenalin, the active extract of the suprarenal organ. It is probably more valuable in preventing than in checking hæmorrhage, and is largely used in intranasal work; it is prepared in the dry form, since it loses its power when kept in solution more than an hour or two. The addition of cocaine to its solution increases its activity. (*d*) A large class of drugs of the astringent class are employed empirically under varying circumstances to assist in hæmostasis—*e.g.*, turpentine, hamamelis, ergot, acetate of lead, etc.—but it cannot be said that their action, though appreciated, is fully understood. (*e*) Finally, it is most important in cases of internal hæmorrhage, as from the lungs or gastro-intestinal canal, to keep mind and body quiet, and there is no agent under these circumstances more valuable than *opium* and its salts.

6. **Direct Pressure,** as already mentioned, when available, is always effective—at any rate, for a time. General oozing from cut surfaces, which can be brought into apposition as in an amputation wound, may be checked by applying a firm bandage over them. In cavities or hollows, either natural or made by operation, bleeding may be stopped by packing with strips or graduated layers of sterilized gauze or lint. Such dressings should be retained firmly in position for twenty-four hours, after which, if no further hæmorrhage has occurred, the bandages may be slackened; but it is usually advisable to retain the deep plugs for another day or two.

When the bleeding is more serious, and originates from some definite vessel or vessels, more precise measures have to be adopted. Digital pressure over or on the cardiac side of the bleeding spot suffices to arrest it for a time, whilst preparations are being made to secure the wounded vessel. If possible, a ligature should be applied with antiseptic precautions, but other means have been used:

1. **Acupressure** was introduced by the late Sir James Simpson in order to obviate the use of ligatures, but is now only used in exceptional circumstances. A needle was passed either under the vessel from the skin, or over the vessel from the surface of the wound, and with it was sometimes combined the pressure of a loop of silk or wire passed figure-of-8 fashion around the ends of the needle.

2. **Forcipressure** is a plan for stopping hæmorrhage by crushing the divided end of the vessel between the strong and deeply serrated blades of a pair of forceps with scissor-handles provided with a catch; those known by the name of Spencer Wells or Greig-Smith are the most convenient. In dealing with small vessels, it is quite sufficient to leave the forceps applied for a few minutes, perhaps twisting them before removal; but with the larger it is advisable to apply a ligature, although it is claimed for the Greig-Smith pattern that the artery is so thoroughly crushed that this is unnecessary. In deep wounds, where it is difficult, or almost impossible, to tie the vessel, the forceps may be incorporated in the dressings, and not removed for twenty-four hours or longer, according to the size of the vessel.

3. **Torsion** was formerly used as a means of sealing the ends of divided vessels, before aseptic ligatures were introduced. It is still occasionally employed for small vessels after forcipressure, and is specially useful in skin-grafting. The effect is to cause rupture of the inner and middle coats just above the spot grasped, and these curl upwards into the lumen of the vessel, whilst the outer coat is twisted up beyond. A coagulum forms upon the injured structures, and the subsequent processes to secure permanent occlusion are similar to those described above.

4. **Ligature** is at the present day the method most frequently used for arresting bleeding from a definite source.

The **material** should be of sufficient strength to secure the vessel, of sufficient resistance to maintain its hold in spite of being soaked in the body fluids, and yet of such quality as to be absorbed, or so pure and unirritating as to become encapsuled in the tissues. *Catgut* suitably prepared is frequently employed. It is obtained from sheep's intestines by allowing them to putrefy in water, and then scraping away the mucous and muscular coats, leaving only the elastic basement membrane of the submucosa; this is dried and twisted into the long strands of commercial catgut. When soaked in blood-serum, this substance swells up into a soft, pulpy mass in half an hour, so that it is necessary to harden and render it more resistant before use, as well as to sterilize it thoroughly. It is most effectively prepared by immersion in a mixture of chromic and sulphurous acids in accordance with Lord Lister's original instructions.* The length of time that catgut remains unabsorbed in the tissues varies with the length of its stay in the chromic acid solution, and material calculated to last ten, twenty, thirty, or forty days can be obtained from instrument makers. It is always essential to sterilize catgut thoroughly before use, and the best methods have been discussed at p. 277.

Sterilized silk and linen thread are also employed, whilst animal tissues, such as kangaroo tendon and strips of ox aorta, have their advocates. Ballance and Edmunds advise the use of gold-beaters' skin, prepared from the peritoneum of an ox, as a material for tying vessels in their continuity, and excellent results have followed its employment. Pagenstecher's celluloid ligature may also be considered a safe and harmless material, and can be sterilized by boiling.

The immediate *effect* of a ligature *on the arterial wall*, if the vessel has been tied in the usual way, is to divide the inner and middle coats, which are separated from the outer, and curl up slightly, whilst the outer coat is constricted and thrown into folds within the grasp of the ligature (Fig. 92). If an artery is tied in its continuity, the same effect is produced on each side of the ligature. The changes already described, by means of which the artery is obliterated and transformed into a fibro-cicatricial cord, manifest themselves in due order. If the ligature, however, is *infected* and irritating, it has to cut its way out through the vessel wall by an ulcerative process akin to the separation of a slough, thus exposing the patient to the risk of secondary hæmorrhage.

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* *Brit Med. Journ.*, January 18, 1908.

Division of the inner and middle coats is not an essential element in gaining satisfactory occlusion of a vessel, for it can also be effectively accomplished by bringing the vascular tunics into close approximation with a broad animal ligature applied by what is known as a 'stay knot' (p. 328) without harming the tunica intima.

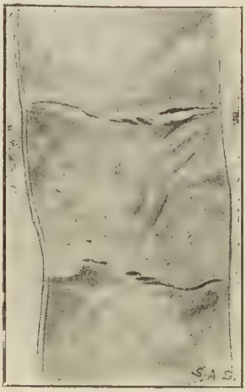

FIG. 92.—EFFECT OF TYING A LIGATURE FIRMLY AROUND AN ARTERY.

The ligature was tied at two levels, and the artery then laid open longitudinally.

Arterial Hæmorrhage.

Three forms of arterial hæmorrhage are described—viz., primary, reactionary, and secondary.

I. **Primary Arterial Hæmorrhage** is met with under two conditions—(1) From an open wound; or (2) where an artery is ruptured or punctured subcutaneously, so that extravasation occurs into the tissues.

A. **From an Open Wound.**—The blood is here poured forth upon the surface, and escapes freely, so that the full constitutional effects are experienced.

The *principles* that guide us in its **Treatment** may be enunciated as follows:

1. *The vessel must be secured at the bleeding-point,* an operation to expose it being undertaken if necessary. However infiltrated the part, the rule of cutting down to expose the wounded vessel is to be adhered to, and this for two reasons: (*a*) It is often impossible to know the exact source of the hæmorrhage unless it is laid bare. Thus, the bleeding from a punctured wound of the front of the leg, which was apparently derived from the anterior tibial artery, was proved on incision and careful dissection to come from the peroneal, the wound extending backwards between the bones. In the axilla and groin such uncertainty often exists. (*b*) Proximal ligature of a vessel at some distance above the bleeding spot is often insufficient to arrest the hæmorrhage, since the collateral circulation is quickly established. In one or two regions, however, such as when the vessel wounded is the deep palmar or plantar arch, or one of the secondary branches of the external carotid in the pterygoid region, the dissection to expose the bleeding-point may be so difficult and dangerous, or so likely to be followed by damaging adhesions, that the above-mentioned rule is departed from and proximal ligature is permissible.

2. *Both ends of the wounded vessel must be secured* if it is completely divided, whilst if it is only punctured, a ligature must be placed on each side of the puncture, and the complete division of the vessel

effected. The readiness with which a collateral circulation is established justifies such treatment in the case of all arteries of large size.

3. It is *only needful* to undertake the measures detailed above in cases *where primary hæmorrhage is actually proceeding.* If it has been once arrested, it is unnecessary to search for the bleeding spot; the wound should be dressed with the utmost care not to dislodge clots or disturb the parts. If, however, the patient is very faint and collapsed, and the surgeon has reason to anticipate that a large trunk has been injured, it may be needful to seek for and tie it at once; otherwise recurrent hæmorrhage is likely to ensue when the heart's action becomes more vigorous.

In the actual treatment of any particular case, **temporary arrest** of the bleeding may usually be effected *by digital compression* either of the bleeding-point or of the main trunk at a favourable spot nearer to the heart, against some resisting structure, such as a subjacent bone. The *common carotid* is controlled by grasping the neck from behind, and compressing the artery by the fingers placed along the anterior border of the sterno-mastoid against the transverse process of the sixth cervical vertebra (Chassaignac's tubercle). Such pressure will also control the vertebral and inferior thyroid vessels. The *subclavian* is to be compressed in the third part of its course against the first rib by the finger or thumb placed immediately behind the clavicle, in the angle between it and the sterno-mastoid, the pressure being made downwards and inwards. A good deal of force is sometimes required in order to maintain the pressure, and this may be gained by superimposing the fingers or thumb of the other hand. When the pressure is to be kept up for some time, the padded handle of a door-key may be employed in the same way, or an incision may be made and the vessel exposed, and controlled by direct digital pressure. The *facial* artery is compressed against the lower jaw just in front of the masseter muscle; the *temporal* artery against the zygoma just in front of the ear; the *occipital* at a spot about 1¼ inches from the occipital protuberance against the superior curved line. To control the *brachial* artery, the arm should be grasped from behind, and the fingers pressed inwards along the inner margin of the biceps against the humerus. The *abdominal aorta* is controlled in slim individuals with ease by pressure through the abdominal wall against the body of the third lumbar vertebra a little above and to the left of the umbilicus—*i.e.*, just above its bifurcation; in stout persons this is impossible. The *common femoral* artery is best compressed immediately below Poupart's ligament. The surgeon should stand on the same side of the patient as the artery to be controlled, and use the finger-tips to press the vessel directly backwards against the pubic ramus. The fingers of one hand placed over the other may sometimes be necessary to maintain sufficient command. Care must be taken not to let the vessel roll aside, and so escape compression.

As digital compression cannot, however, be comfortably maintained for long, *mechanical compression* of a limb, as by a tourniquet or elastic bandage, must be requisitioned. A useful contrivance in cases of emergency is fashioned out of a large handkerchief, which is knotted loosely round the limb, and tightened by the rotation of a piece of wood inserted beneath it; a pad is also placed over the main artery, which is thereby compressed.

The wound is then, if need be, enlarged by incisions, which, whilst laying the parts freely open, should inflict the least possible damage on surrounding structures. All coagula are removed, the parts are purified, and a search made for the wounded vessel. It may be needful to relax the tourniquet, and allow a jet of blood to escape, in order to ascertain its position. Both ends should be sought for and tied, a proceeding often easier said than done. This especially applies to the distal end, which retracts, and possibly does not bleed at the time of operation, but may do so when the collateral circulation becomes established.

B. For **Subcutaneous Rupture of an Artery,** see p. 299.

II. **Intermediate or Reactionary Arterial Hæmorrhage** is the term applied to bleeding which recurs within twenty-four hours of an accident or operation. It may result from two chief causes: (*a*) Defective application of a ligature, which comes undone from being badly tied (a ‘ granny ’ knot), or slips off from including within its grasp other structures as well as the arterial wall; or (*b*) the coagula lying in the mouths of divided vessels are not sufficiently firm to withstand the increasing blood-pressure which supervenes after the shock has passed away, or which may be due to excitement or the injudicious administration of stimulants. It is usually due to the second of these causes, and is then not very serious, inasmuch as it can only arise from the smaller vessels, all the larger ones having probably been recognised and tied during the operation.

Treatment.—Elevation and the pressure of a firm bandage are often quite sufficient to arrest this form of bleeding; but if unsuccessful, the wound must be opened up, washed out with hot salt solution, and any bleeding vessels tied. The actual cautery may even be employed to check oozing from cicatricial surfaces, and if it is not allowed to touch the skin, and the wound kept aseptic, no delay in healing need be occasioned. Should the bleeding persist, the wound should be firmly packed.

III. **Secondary Hæmorrhage.**—Under this title are included all forms of hæmorrhage from wounds which occur after the lapse of twenty-four hours. It is usually due to infection, and was formerly very common, often leading to a fatal termination; since the introduction of antiseptic surgery it is but seldom seen, except where asepsis cannot be fully maintained, as in the mouth, pharynx, etc.

The **Essential Cause** is almost always **infection** of the wound. In a vessel which has been divided and ligatured, as on the face of an amputation stump, the projecting end of the vessel beyond the ligature is practically dead tissue, and therefore readily attacked by bacteria, which transform it into a slough which, together with the infected ligature, has to be cast off, and, when this happens, bleeding may occur. In addition to this, however, the infection of the wound involves a suppurative inflammation around the vessel (periarteritis), which results in a softening of the vascular tunics by the bacterial toxins, and this may progress in time to such an extent as to render them incapable of resisting the blood-pressure, so that, sooner or later, they give way. This latter condition is especially seen in vessels tied in their continuity, and also occurs in the secondary hæmorrhage which is sometimes seen in connection with abscesses in the neighbourhood of large vessels.

Anything which interferes with the vitality of the vessel wall may serve as a **Contributory Cause,** such as the separation from its sheath for too great an extent, thereby cutting off its blood-supply; or a diseased condition of the arterial wall, as from atheroma, or an unhealthy condition of the patient's blood, or undue elevation of blood-pressure, as in Bright's disease.

After ligature of large vessels, such as the innominate, first part of the subclavian, or common iliac, secondary hæmorrhage may occur apart from infection, if the inner and middle coats have been divided by the ligature. The crumpled-up outer coat exposed just above the ligature by the retraction of the inner and middle coats is insufficient to withstand the blood-pressure in such large vessels, and undergoes an aneurismal dilatation, which is certainly followed by hæmorrhage at an early date.

The **Phenomena** are almost always preceded by those of infection of the wound, to which a slight occasional loss of blood is added. This continues with more or less frequency and severity, until the patient is either worn out by the constant repetition of small losses, or destroyed by one or two severe gushes from the larger vessels. The earlier the bleeding occurs, the less serious it is, as it probably comes from the smaller vessels, and can be easily dealt with. When, however, it does not supervene till late, as on the tenth or twelfth day, it usually arises from the larger trunks, and is increasingly severe. When originating from a vessel tied in its continuity, it generally comes from the distal end, since repair is here less effective than on the proximal side of the ligature, and resistance to bacterial infection less vigorous. The explanation of this is that the vasa vasorum reach the artery from the sheath, and run with the blood-current. The separation of the sheath and the application of the ligature necessarily cut off the blood-supply of the vessel wall just distal to the ligature.

Treatment.—The case must be watched night and day until the wound is healthy, as although the bleeding may have ceased for a while, it may break out again at any time. If the wound is in a limb, a tourniquet should be lightly adjusted above it as a precautionary measure, so that at a moment's notice it may be tightened.

Whenarising *from an artery entirely divided across*, as in an amputation stump, elevation of the part after redressing and firm bandaging may be all that is needed in early cases. A recurrence will necessitate the opening up of the wound, and the application of ligatures to the bleeding vessels, if practicable. The actual cautery may be employed where the tissues are too rotten to hold a ligature. Sloughs may be cut or scraped away, and the wound packed with gauze and firmly bandaged. If this fails, the artery must be tied just above, or re-amputation performed. When the bleeding comes from the main vessel near the trunk, as after amputation at the shoulder or hip, proximal ligature can alone be depended on, should local treatment be unsuccessful.

When coming *from an artery tied in its continuity*, the wound is opened up, and the artery secured again above and below, whilst every effort is made to combat the infection. Failing this, proximal ligature may be practicable, but for the large vessels of the trunk pressure may be the only resource. Should re-ligature at a higher spot fail or be considered inadvisable, as is often the case in the leg, amputation must be undertaken without delay.

Venous Hæmorrhage.

Bleeding from the smaller veins rarely requires much attention, in that the walls, when once divided, rapidly collapse, and this effectually checks further loss of blood; but if the larger veins are involved, or if the walls are thickened and rigid, as in varix, a very considerable amount may be lost, the blood welling up in a dark, purplish stream from the wound, and rendering its arrest the more difficult from the fact that, except in veins of the largest size, there is no definite jet or gush to guide one to the wounded spot. **Treatment.**—Divided veins are usually tied in the same way as arteries, but it is often possible to secure a puncture or tear in a large vein by a lateral ligature without occluding its whole circumference. In amputations it is usual to tie both the main artery and vein. Where it is difficult to reach a vein in order to tie it, the wound may be packed.

Secondary Hæmorrhage from veins is not common, but arises occasionally from infection around a large vein which has been punctured and a lateral ligature applied, or a branch of which has been tied at its point of union with the main trunk. Under aseptic conditions repair of the wounded venous wall is effected without cessation of the circulation in the main trunk. If the wound becomes infected, the ligature is invaded by germs, as also the portion of vein wall within its grasp. In the smaller veins the inflammation induced will result in a protective thrombosis; but in a large vessel, such as the internal jugular, where the blood-stream is rapid, thrombosis may be hindered in its occurrence, and hæmorrhage may result from the wall giving way. The bleeding from cases of this description will usually be severe, but can be easily controlled by pressure or ligature of the whole trunk above or below the wound.

The Entrance of Air into Veins is, fortunately, a rare occurrence, as it is always fraught with grave danger to the patient, inasmuch as it interferes seriously with the circulation, and may even cause death. The air sucked into the veins is carried up to the right side of the heart, and there becomes entangled in the columnæ carneæ, and is churned up into a frothy spumous mixture, which the heart can only eject with difficulty.

The **Cause** is usually a wound of some vein in what is known as the ' dangerous region ' of the neck (lower portion) or axilla, or even of such unlikely structures as the pelvic veins or cranial sinuses. During inspiration the movements of the thorax exercise an aspiratory or suction effect upon the blood in the larger veins, and hence any condition which prevents the collapsing of the walls of the veins, or brings about what is termed their *canalization*, predisposes to this accident. Thus they may be held open at spots where they pierce the deep fascia or the platysma; if the coats are thick and rigid from inflammation, or surrounded by indurated tissue, or buttonholed as by excision of a portion of the walls or division of a branch close to the main trunk, or if undue traction is exercised upon the pedicle of a tumour containing a wounded vein, then the orifice may remain patent, and air can be sucked in. If, however, the veins are very distended, as is often the case in the operation of tracheotomy, then a wound, even in the dangerous area, usually results in loss of blood rather than entrance of air.

The chief **sign** is a hissing, gurgling, or sucking sound, which is quite characteristic. A few bubbles of air may also be seen clinging about the aperture in the vessel. If only a small amount has entered, or if the entry is made slowly, no bad results may follow; but the usual effect is to produce severe faintness, and if the patient is conscious, a feeling of dyspnœa and distress. The pulse becomes rapid and almost imperceptible, the pupils widely dilated, and death may follow, preceded perhaps by convulsions, although the fatal issue may be postponed for a few hours. If the patient survives, no after-effects remain.

Treatment.—This accident can usually be avoided by dealing cautiously with all veins in operations about the neck, securing them, if possible, by ligature or forceps before their division. Should it occur, any fresh entrance must be at once checked by placing a finger over the bleeding-point or pouring lotion into the wound. The wound in the vein should be at once closed. To combat the general symptoms, it is essential to maintain a good supply of blood to the brain. The head is lowered, and, if need be, the limbs raised and bandaged, or the abdominal aorta compressed. Stimulants and artificial respiration are used in order to maintain the heart's action and to overcome the pulmonary obstruction. Warmth and friction are also applied to the extremities.

Methods of Dealing with Hæmorrhage from Special Sources.

Secondary Branches of the Carotid.—It may be difficult to secure the divided ends of these vessels either in the neck or head, *e.g.*, in a cut throat or a punctured wound of the pterygoid region. Under such circumstances, ligature of the external carotid between the superior thyroid and lingual has been recommended as more satisfactory than tying the common carotid, since the cerebral circulation is not thereby affected.

Vertebral Artery.—The source of such bleeding may be difficult to ascertain, as it is scarcely possible to compress this vessel without also including the carotid; and hence mistakes in diagnosis have often arisen. It may be feasible, however, to control the carotid alone by pinching it up by the fingers placed on either side of the sterno-mastoid, without interfering with the vertebral. *Treatment* must follow the usual course of cutting down and tying at the bleeding-point, if possible. To do this, the incision must be enlarged, or a new one made along the posterior border of the sterno-mastoid in order to define the transverse processes of the vertebræ. In the upper part of its course the vessel may be secured by clipping away a transverse process if necessary, due care being taken of the nerve roots; otherwise plugging of the vertebral canal or the use of styptics must be depended on. It is most essential that the carotid should not be tied by mistake in these cases, as thereby more blood is directed to the vertebral trunk, and the bleeding is correspondingly increased.

The **Internal Mammary Artery** rarely calls for treatment, since an accidental wound of this vessel is usually complicated with some graver mischief to heart, liver or lungs. If recognised, tie at the bleeding spot, possibly removing a costal cartilage to gain access. The vessel lies about ½ inch outside the border of the sternum.

Intercostal Hæmorrhage usually results from penetrating wounds also involving the rib, and is not easily stopped on account of the position of the vessels in the groove. *Treatment.*—Incise the periosteum longitudinally along the lower border of the rib, and detach it and the vessels from the groove; or remove a portion of the bone, and thus expose the bleeding-point; or in some cases a suture passed round the rib a little above the injury has sufficed; or again, pressure may be employed by pushing a piece of aseptic gauze, like a pocket, through the wound in the pleural cavity, and then stuffing it tightly with wool or strips of gauze, so that on pulling upon it the vessel may be effectually compressed.

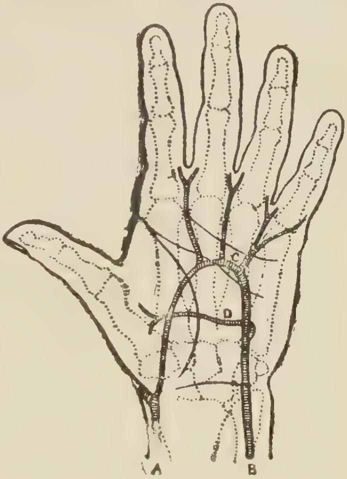

FIG. 93.—HAND, TO SHOW POSITION OF PALMAR ARCHES.

A, Radial artery; B, ulnar artery; C, superficial arch; D, deep arch.

Wounds of the **Palmar Arches** were formerly much more dreaded than they are at present, when effective asepsis and the use of the elastic tourniquet allow us to explore the depths of a wound without much danger or difficulty. The position of the wound will usually indicate whether the bleeding comes from the superficial or deep arch, but in case of doubt it is well to remember that pressure on the ulnar trunk mainly affects the superficial arch, whilst pressure on the radial will chiefly influence the deep. A wound of the superficial arch presents little trouble in treatment, as it can be readily secured by catch forceps and ligature; but the deep arch is not so easily dealt with. It lies just over the bases of the metacarpal bones (Fig. 93, D), and to expose it the wound must be freely enlarged by a longitudinal incision, and the tendons turned on one side or separated. It may be possible to secure the vessel by forcipressure forceps, and these may be left on for twenty-four hours if a ligature cannot be applied. Of course, the strictest asepsis is needful in such cases, and passive movement of the fingers must be early undertaken, in order to prevent troublesome adhesions. Failing such means, or in infected cases, the wound is packed with sterilized gauze, and over this the fingers are firmly bandaged. The patient is kept in bed for a few days, and the arm elevated. Pressure on the main vessels above is scarcely necessary if the compress is accurately applied. The bandages may be relaxed at the end of twenty-four hours, but the deep dressing should, if possible, not be touched for three or four days. If, in spite of this, bleeding recurs, the main vessel or vessels of the limb must be tied. Ligature of the ulnar and radial arteries at the wrist is generally insufficient to control it, as there is often a communicating branch of some size passing from the anterior interosseous to the deep arch, and hence it may be needful to secure the brachial artery, ascertaining first, however, by pressure that such would be efficacious; for occasionally there is a high division of the brachial, or a vas aberrans may exist, which would compel the surgeon to tie the third part of the axillary.

Bleeding from the **Plantar Arch** must be conducted on similar lines.

The **Gluteal, Sciatic,** or **Pudic** arteries may be wounded by stabs in the buttock. *Treatment.*—Enlarge the wound in the direction of the fibres of the gluteus maximus, *i.e.*, downwards and outwards, and secure the bleeding vessel. The gluteal trunk emerges from the pelvis at the junction of the middle and inner thirds of a line from the posterior superior iliac spine to the great trochanter; the pudic crosses the ischial spine at the junction of the middle and lower thirds of a line from the posterior superior iliac spine to the tuber ischii. The sciatic emerges from the pelvis just above and a little external to the latter spot. The pudic may also be divided in the perineum by a penetrating wound. Failing ligature of any of these arteries at the seat of bleeding, the internal iliac may need to be secured.

Hæmophilia.

By hæmophilia, or the hæmorrhagic diathesis, is meant a disease, either congenital and hereditary, or casual and accidental, characterized by a tendency to persistent and uncontrollable bleeding from slight wounds, whether open or subcutaneous. This condition is often associated with extravasation of blood into the joints, and certain consecutive phenomena (Chapter XXIII.). The family history of the hereditary cases is interesting, the disease being usually transmitted through the females of one or more generations to the males, whilst the former may escape entirely. The cause of this affection does not lie in the vessels, but in the blood, and is probably due to an insufficiency or imperfection of the fibrin ferment, or to the presence of some anti-coagulable substance. Unless hæmorrhage is actually occurring, nothing abnormal is noticed, but any injury is sure to be followed by excessive bleeding; spontaneous subcutaneous ecchymoses frequently occur, as also bleeding from the mucous membranes. Hence no operations must be undertaken on such patients unless absolutely urgent, even such a small matter as the extraction of a tooth having proved fatal.

The **Treatment** of hæmophilia should be directed more to correcting the defect in the blood than to pursuing the usual practice in dealing with hæmorrhage. The application or administration of hæmostatics, and of substances which tend to promote coagulation and the formation of fibrin, should be resorted to. Calcium lactate, 10 to 20 grs. in ½ pint of water given by the rectum, or 5 to 10 grs. by the mouth, repeated two or three times a day, is decidedly useful, whilst fibrin ferment, suprarenal extract, and cocaine should be employed locally. Position and pressure are attended to, and in severe cases the actual cautery may prove useful, or the prolonged application of cold. The subcutaneous or oral administration of sterilized horse or rabbit serum in doses of from 10 to 30 c.c. has been recently recommended. Antidiphtheritic serum may be employed instead.

CHAPTER XIII.

INJURIES AND DISEASES OF ARTERIES—ANEURISM—LIGATURE OF ARTERIES.

Injuries of Arteries.

Contusion of an artery is the result of violence applied directly to the vessel wall. If atheroma or calcification exists, thrombosis often follows slight injuries, and dry or senile gangrene may ensue; but in healthy arteries a good deal of violence is needed to produce such an effect, as their natural elasticity enables them to yield or slip aside, and thus the consequences are usually insignificant.

Rupture or **Laceration** may also follow blows or strains, or may result from fractures or dislocations, or from attempts to reduce old-standing dislocations, or to break down intra-articular adhesions. If the rupture is **partial,** the inner and middle coats are usually torn, and by projecting into the lumen of the vessel constitute a valve which prevents the passage of blood, and leads to subsequent thrombosis and occlusion. In cases where the lesion is limited to one side of the vessel, the clot may become organized over that spot, narrowing but not interfering with the lumen, and leaving an area of weakness from which an aneurism may subsequently develop. A dissecting aneurism (p. 311) may also result under special circumstances from such an accident. When complicated with an infected wound, an ulcerative form of peri-arteritis may ensue, giving rise later on to secondary hæmorrhage.

Complete Rupture of an artery often leads to but little hæmorrhage in a severe lacerated wound, such as is produced when a limb is torn off: the inner and middle coats give way at a higher level than the adventitia, and curl up within it, whilst the outer coat and sheath contract over them, and thus prevent bleeding. If, however, the artery is ruptured in a subcutaneous injury, such as a fracture or dislocation, extensive interstitial extravasation often ensues. A similar condition may ensue from a punctured wound of a vessel, where the track leading to it is valvular or becomes closed by clot or some external application.

Symptoms.—The patient usually feels a snap, as though something had given way, accompanied by a sudden pain, localized to the injured part, and often shooting down the limb in the line of the vessel. These are succeeded by the following phenomena: (*a*) *Locally*, the formation of a diffuse, rapidly increasing swelling, the skin over which is at first normal, but soon becomes distended and bluish, and finally bright red and œdematous, when the tumour is threatening to give way. There is no increased local heat except in the later stages. Distinct pulsation is usually present at first, and some amount of thrill and bruit, synchronous with the heart's action, although these subsequently become less obvious. (*b*) *Distally*, diminished sensibility in the limb quickly follows, together with loss of pulsation in the vessels and a fall of temperature. It lies more or less useless and flaccid, and in colour is either white and blanched, or may be congested and œdematous if the extravasated blood presses upon the venous trunks. (*c*) *Generally*, the signs of hæmorrhage and shock manifest themselves in varying degree, according to the amount of blood lost and the character of the violence.

Results.—(1) The swelling may increase steadily in size until the skin becomes so distended as to *rupture* or slough, and then, if help is not at hand, the patient dies of hæmorrhage. Occasionally the bleeding continues into an internal cavity, or into the tissues of a limb, to such an extent as to cause death without any external loss of blood. (2) *Suppuration*, accompanied by the general signs of fever, may result from auto-infection, or from the entrance of bacteria through the small valve-like wound. The whole swelling becomes red, hot, œdematous, and excessively tender, looking like a large abscess. Rupture and external hæmorrhage will probably conclude the case if surgical assistance cannot be obtained. (3) The pressure of the extravasated blood upon the veins or on the arteries needed for the collateral circulation may determine *gangrene* of the extremity, which is almost always of the moist type. (4) The process may become more or less *limited* after a time by coagulation occurring in the divided mouth of the vessel, which is thus occluded. Collateral circulation may be established, and thereby the health and vitality of the limb are maintained, whilst the blood-clot is absorbed or organized.

The **Treatment** is necessarily the same as for a divided artery communicating with an open wound—viz., to cut down on and tie both ends. The circulation is first temporarily arrested by an elastic or other tourniquet, a free incision made, and all coagula removed. The bleeding-points are then sought for and tied, the tourniquet being relaxed to allow them to become evident. If the distal end cannot be found, the wound is not closed, but should be packed with gauze, and allowed to granulate, a tourniquet being kept loosely about the limb ready to be tightened at any moment, if necessary. When suppuration is threatening, the same plan must be adopted—viz., free incision and tying the ends of the vessel if they can be found; but in cases where from the œdematous and unhealthy state of the surrounding parts this is impracticable, it will be necessary either to tie the main trunk on the cardiac side of the rupture, or to trust to pressure. If gangrene is imminent, or if secondary hæmorrhage occurs, amputation is usually the only resource.

Penetrating Wounds of arteries, if completely dividing the vessel, are always followed by hæmorrhage, although the blood may be unable to escape externally. If a large artery is cleanly cut across, the bleeding is copious, whilst from a small vessel it soon ceases, owing to the contraction and retraction of the coats. When an artery is 'buttonholed'—*i.e.*, when a small segment of the wall is cut through—the hæmorrhage is often continuous and prolonged, since retraction cannot take place. The treatment of this condition consists in completing the division of the injured trunk, if it is a small one, thus allowing of contraction and retraction, or, if the vessel is of large size, in tying it above and below the opening, and dividing it between the ligatures.

If the wound is in the long axis of the vessel, it gapes but little, and the loss of blood is often slight, whilst if transverse or oblique, both contraction and retraction tend to increase the size of the opening, rendering it more nearly circular, and therefore the hæmorrhage in such cases is considerable.

If an artery is divided close to its origin from a large main trunk, the blood escapes with a jet, the strength of which is proportionate to the blood-pressure in the main trunk, and not to the size of the vessel divided. In such a case the main trunk must be tied above and below the wound, and divided between the ligatures, and the distal end of the divided branch also secured.

A good many attempts have been made of late to effect the union of wounds in the walls of arteries without causing their obliteration, and with some success. Small longitudinal wounds may certainly be sutured, the stitches being of the finest silk and applied so that the edges of the tunica intima are brought accurately into apposition; Heidenhain reports a case where a wound 1·5 centimetres long in the axillary artery was successfully sutured in this way. End-to-end union of a divided artery has also been effected,* the method usually adopted being that suggested by Carrel in 1902. The vessel is controlled above and below by suitable hæmostatic clamps, such as Crile's; blood-clot is washed out of the cut ends by sterile salt solution, and the adventitia is trimmed off. The suture material employed must be the very finest silk sterilized in vaseline. The anastomosis is effected by the use of a circular continuous suture, or better by a continuous mattress suture through the intima, and a reinforcing continuous running stitch outside. The difficulty lies not so much in effecting union as in doing so without determining thrombosis either at the site of anastomosis or at the point of application of the clamps. The greatest gentleness is obviously necessary in all these manipulations.

In punctured wounds of arteries the size of the penetrating body is all-important. A vessel may be traversed by a needle without hæmorrhage or any subsequent ill effect, but a larger puncture results in extravasation. If it ceases after a time, the blood-clot is absorbed, and the wound in the vessel closed by a cicatrix, which may subsequently yield to the blood-pressure, and give rise to a circumscribed aneurism. This occurrence is not unfrequent in the neighbourhood of the wrist from glass wounds, involving the radial or ulnar trunks, and hence is not uncommon among window-cleaners or mineral-water bottlers.

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* J. B. Murphy, *Medical Record*, January 16, 1897.

Arterio-Venous Wounds follow penetrating injuries which involve an artery and vein lying in close contact—*e.g.*, at the bend of the elbow between the median basilic vein and the brachial artery, in the neck between the internal jugular and carotid, in the groin between the femoral vessels, and occasionally in the orbit. They are also met with in military surgery, owing to the shape of the modern bullet and the limited amount of danger caused by it in the soft tissues. Two conditions may result.

An **Aneurismal Varix** is produced by a direct communication between an artery and a vein, no dilated passage intervening between the vessels (Fig. 94, *A*). The venous walls, unfitted to withstand arterial pressure, are thereby dilated and rendered varicose, A pulsating venous tumour results, the dilatation extending for a variable distance above and below the opening, and at each beat of the heart a loud whizzing sound can be heard, likened by some authors to that caused by an imprisoned bluebottle buzzing in a thin paper bag. On palpation the thrill of the blood as it enters the vein can often be detected.

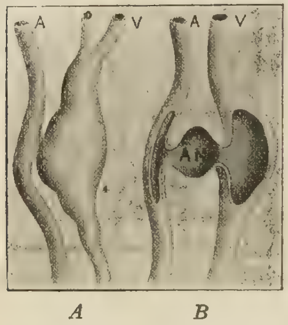

FIG. 94.—DIAGRAMS OF *A*, ANEURISMAL VARIX AND *B*, VARICOSE ANEURISM.

A, Artery; V, vein; AN, aneurism.

Treatment.—Nothing is usually required beyond the application of an elastic bandage or support to prevent further enlargement. Should pain or inconvenience arise in spite of this, it may be possible to repair the wound in the arterial wall by suture, or, failing that, the artery must be secured above and below the abnormal communication with the vein. Occasionally the latter is so distended that it has to be removed before the artery can be reached.

A **Varicose Aneurism** differs from the above in that an aneurismal sac exists between the artery and the dilated vein (Fig. 94, *B*). It is produced when the vessels are placed at a short distance from each other, or when extravasation of blood has separated them. The aneurism is of the false type, its walls being composed of newly-formed cicatricial tissue; it is almost certain to become diffuse. The physical signs are similar to those of aneurismal varix, except that the aneurism can sometimes be detected by palpation, whilst a soft bruit may be heard over it.

Surgical **Treatment** is always required in these cases. Simple ligature of the artery above and below the abnormal communication will usually suffice, allowing the blood in the sac to coagulate; the veins will subsequently diminish in size, when the arterial blood-pressure is removed. Not unfrequently the vein overlaps the artery, and has to be tied and removed before the sac of the aneurism is reached; it is then better to excise the sac and tie the artery above and below.

Inflammation and Degeneration of Arteries.

1. **Traumatic Arteritis** is the result of injuries, such as total or partial division of the vessel, laceration, bruising, etc. The phenomena are merely those of repair, resulting in closure of the wound or occlusion of the vessel; they have been already described.

2. **Infective Arteritis** results from bacterial invasion of the arterial wall, and that usually from without (periarteritis) and in connection with infected wounds and ligatures, or spreading ulceration. It is characterized by hyperæmia and softening of the vascular tunics, the fibres of which lose their cohesion with each other, owing to the peptonizing action of the toxins. In the smaller arteries thrombosis usually occurs and seals the vessel; but in the larger there is considerable danger of bleeding. Secondary hæmorrhage from arteries tied in their continuity is generally due to this cause, as also bleeding from phthisical cavities, the vessels having previously lost the support of surrounding tissues, and being more or less dilated or aneurismal.

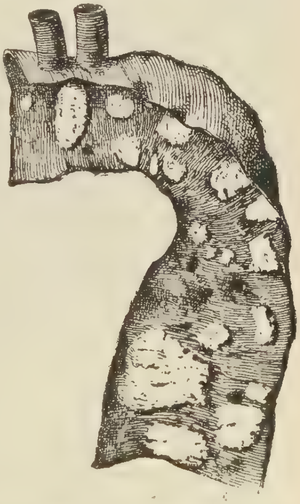
FIG. 95.—ATHEROMA OF AORTA.

3. **Embolic Arteritis.**—When a vessel is blocked by a simple embolus, obliteration is the usual consequence. If the embolus is infective, as in pyæmia or infective endocarditis, an abscess may develop; but if the irritant is less intense, the process may stop short of suppuration, and yet an aneurismal dilatation of the softened wall takes place. The latter process is the most common cause of *spontaneous* aneurism in children and young adults.

4. **Acute Endarteritis** is usually seen in the aorta associated with acute endocarditis, or sometimes in the smaller vessels near in-

flamed wounds. It is evidenced by the presence on the inner aspect of the vessel of more or less raised patches, somewhat pinkish and gelatinous in appearance, soft and elastic in consistency.

5. **Arterio-sclerosis** is the term now applied to a degenerative and inflammatory affection of the arteries, formerly known as *chronic endarteritis*. It usually commences about middle life, and is in many cases merely a physiological sign of the incidence of senility due to the wear and tear of life. In younger patients and in its more severe forms it generally depends on some form of chronic intoxication—*e.g.*, syphilis, gout, alcoholism, or lead-poisoning. It is also induced by excessive and particularly intermittent muscular strain; by cachexia, the result of malignant disease, tuberculosis, or inanition; it may follow as a sequela of acute infections, such as enteric fever or acute rheumatism; or may arise from any condition which leads to persistent increase in the arterial tension—*e.g.*, chronic Bright's disease.

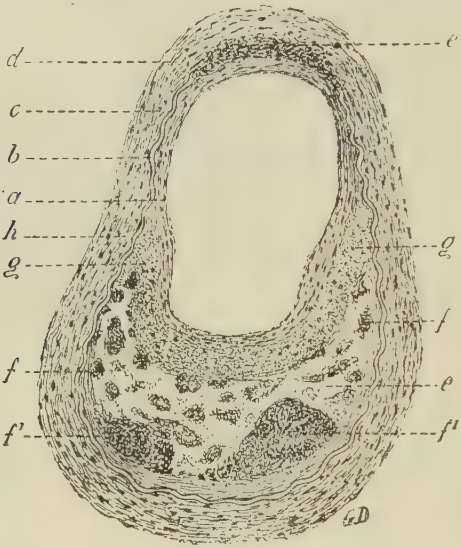

FIG. 96.—SECTION OF ATHEROMATOUS CEREBRAL ARTERY. × 50. (ZIEGLER.)

a, Intima considerably thickened; *b*, bounding elastic lamella of intima; *c*, media; *d*, adventitia; *e*, necrosed denucleated tissue with masses of fatty detritus; *f* and f^1, detritus with cholesterine tablets; *g*, intima infiltrated with leucocytes; *h*, infiltration of adventitia with leucocytes.

The primary changes probably consist in a degenerative loss of elasticity in the middle and outer coats, which is followed by a secondary hyperplasia of the tunica intima. The later changes vary somewhat, according to whether the affection is localized (nodular variety) or diffuse.

Nodular arterio-sclerosis is most common in the aorta and large vessels, and often starts in the convexity of the aortic arch at the spot where the impact of the blood-stream is felt as it is ejected from the ventricles (Fig. 95), or in places where the vessel passes over or around some bony projection, or at the bifurcation of a main artery. In the early stages scattered raised patches are seen on the inner lining of the vessel, translucent and grayish in aspect, and of variable size; the overlying endothelium is smooth and intact. In the later stages fibrosis may occur in the patch, which becomes dull white in colour, and at length calcification may ensue, giving rise to an atheromatous plate. In other cases the process may be followed by fatty degeneration, the patches becoming yellowish in colour and irregular in outline; they are small at first, but increase in size, and coalesce one with another. The contents are now fluid or cheesy in consistency, constituting the so-called 'atheromatous abscess' (Gr. ἀθήρη, 'gruel' or 'pap'), although no true pus exists, the pultaceous material consisting of fatty granules and débris, with oil globules and plates of cholesterine (Fig. 96, f^1). It may be absorbed entirely, leaving a weakened spot in the wall of the vessel, from which an aneurism may arise; or it may be infiltrated with lime salts, and constitute an atheromatous plate; or the tunica intima may give way over it, allowing the contents to be swept into the general circulation, where it probably does no harm, and the raw surface left behind is known as an 'atheromatous ulcer.' The outer coat has by this time become thickened, and hence no immediate ill result follows the breach in the inner coats, although subsequently dilatation may take place, even though cicatrization of the ulcer has occurred. Again, the blood may find its way through the opening into the substance of the wall and strip up the inner from the outer layers, constituting a 'dissecting aneurism'; or a localized thrombus may form, causing occlusion of the vessel.

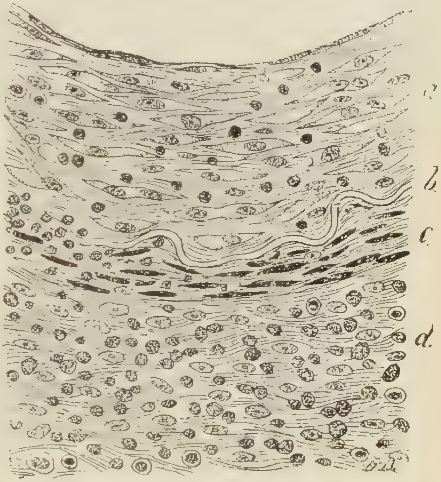

FIG. 97.—SYPHILITIC ARTERITIS. × 150. (ZIEGLER.)

a, Intima greatly thickened by newly-formed fibro-cellular tissue; *b*, fenestrated elastic lamina of Henle; *c*, muscle fibres of media, infiltrated towards the left; *d*, adventitia thickened by cell infiltration and hyperplasia.

Diffuse Arterio-sclerosis occurs in elderly individuals, commonly in the smaller vessels, and may be associated with the nodular variety in the aorta. The changes are similar to those described above, but usually terminate in fibrosis and contraction of the lumen of the vessel; the changes in the intima are followed by thickening of all the coats, but degenerative phenomena are unusual. In the smaller arteries of the brain this change may interfere seriously with the functions of the part; whilst in the vessels of the limbs it may result in what is known as *Endarteritis obliterans,* and lead to gangrene. In some instances even the main trunks may be involved in this affection.

6. **Chronic Syphilitic Endarteritis** is chiefly met with in the late secondary or tertiary stages, and is characterized by an overgrowth of the tunica intima (Fig. 97, *a*), which is subsequently associated with infiltration of the media (*c*), and much more so of the adventitia (*d*). The change occurs in small arteries, especially those of the brain or kidneys, or in the neighbourhood of gummata (Fig. 98), and but rarely in the larger vessels, although a considerable percentage of individuals affected with internal aneurism have suffered from syphilis. It differs from simple atheroma—(1) in attacking small arteries; (2) in affecting the whole circumference of the vessel, and not merely patches; (3) the newly-formed tissue becomes vascular, and does not undergo fatty degeneration; and (4) it leads to narrowing or occlusion of the vessel rather than to weakening and dilatation. When involving the cerebral arteries, various forms of monoplegia, or even hemiplegia, may result.

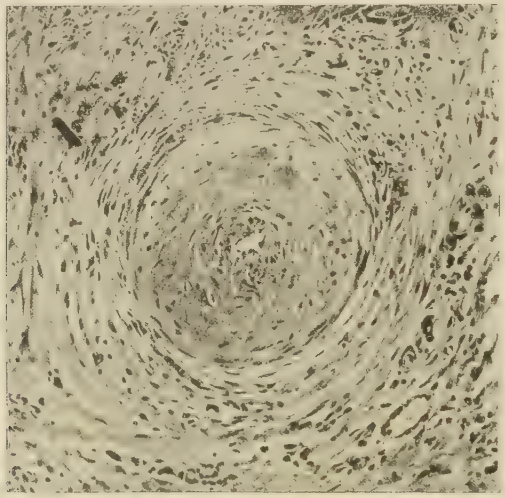

FIG. 98.—SYPHILITIC ENDARTERITIS FROM NEAR A GUMMA. × 120.

7. **Chronic Tuberculous Endarteritis** of a similar type is met with in all places where tubercle is actively developing; in fact, tubercles

are often formed around arterioles, and lead to their obliteration. The tuberculous endarteritis may, however, spread widely beyond the focus of the mischief, and in almost any portion of pulpy granulation tissue this change can be seen.

8. **Primary Calcareous Degeneration** (Fig. 99) is chiefly met with in the smaller arteries of the extremities. It occurs in elderly people at the same time of life as the calcification of cartilages, etc., and commences by the deposit of lime salts in the muscular fibres of the tunica media, constituting a series of calcareous rings which transform the elastic expansile vessels into rigid tubes like gas-pipes, through which alone can pass a fixed and unchangeable minimal supply of blood. It is often associated with generalized arteriosclerosis.

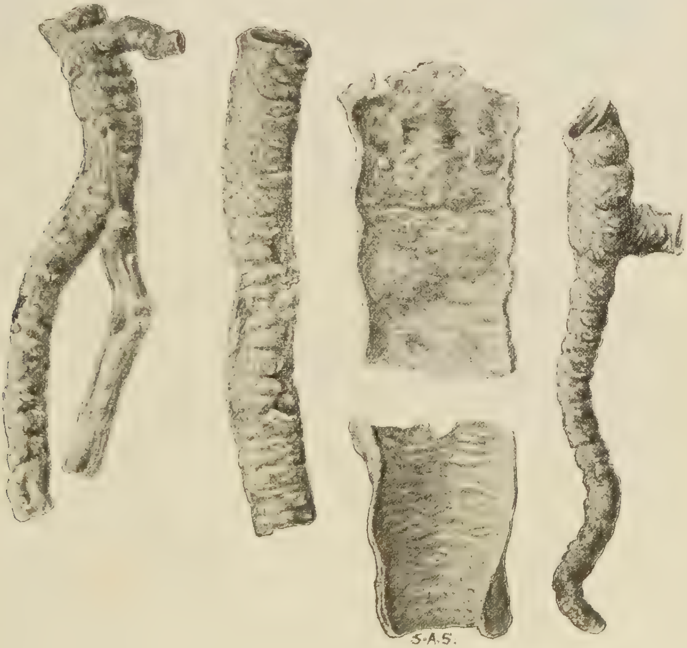

FIG. 99.—PRIMARY CALCAREOUS DEGENERATION OF ARTERIES. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The affected limb passes into a condition of chronic anæmia and impaired nutrition, resulting in coldness of the feet or hands, cramps and spasms of muscles, sensations of pins and needles, etc. The endothelium is not removed except in the later stages, and then thrombosis may be produced, or a similar result may arise from the lodgment of an embolus. Senile gangrene (p. 114) is a common termination.

9. **Amyloid Degeneration** of the viscera commences in the arterial walls, but is described elsewhere (p. 83).

The Effects of Arterial Inflammation and Degeneration are both local and peripheral. *Locally,* **Thrombosis** may be produced whenever the lining endothelium is removed and a raw surface exposed, upon which fibrin can collect. Under this fibrinous coating repair is often effected without further complication: but if the bloodstream is retarded, or the lumen of the tube narrowed, complete thrombosis may follow, the clot extending some distance up or down the vessel, or even from a branch into the main trunk, which may be blocked by this means. **Aneurism** is also a result of any weakening of the arterial tunics. **Obliteration** of the artery is caused, either by thrombosis, or by excessive proliferation of the tunica intima (as in syphilitic or tuberculous disease), or by gradually increasing pressure from without. Lastly, **Spontaneous Rupture** is occasionally produced.

Peripherally, defective blood-supply and consequent **lowered vitality** are the most marked results of arterial disease, leading to various forms of ulceration and gangrene. Thus, senile gangrene is due to calcareous changes in the arteries, fatty degeneration of the heart follows atheroma of the coronary arteries, whilst softening of the brain may ensue from various affections of the cerebral vessels. Similar results may also arise from **emboli** detached from areas of local disease.

Aneurism.

An **Aneurism** is a sac filled with fluid or coagulated blood communicating with the interior of an artery, the walls of which have become dilated.

Causes.—1. **Changes in the Vessel Walls,** by which their resistance to the intravascular pressure is diminished. Many varieties of *disease, e.g.*, atheroma, predispose to aneurismal dilatation, especially if occurring in syphilitic or gouty men about middle life, in whom, although the arterial tunics may be weakened, the power of the heart and the resulting blood-pressure are by no means diminished. The diffuse form of arterio-sclerosis (often associated with calcification) of the peripheral arteries is antagonistic to aneurismal dilatation. Any *injury,* a contusion, a penetrating wound, or a strain, may so interfere with the integrity of the vascular coats as to result in aneurism and, indeed, a cicatrix in an arterial wall must always be looked on as a weak spot predisposing to dilatation. The lodgment of an infected *embolus* in the smaller arteries is stated to be one of the most common causes of spontaneous aneurism in young people.

2. **Increase in the Blood-Pressure** is another factor, especially when due to heavy *strain* or *exertion,* which leads to irregular excitement and increased action of the heart. Steady laborious employment, such as is seen amongst artisans and mechanics, or regular exercise, does not appear to predispose to this condition; but irregular intermittent efforts, in which for the time being every

power is strained to its utmost, are very liable to determine its occurrence. A day's exertion in the hunting or shooting field by an elderly man, accustomed to sedentary occupations, is often the cause of some vascular lesion, such as aneurism, apoplexy, etc. Hence aneurisms are more frequently seen amongst men than in women, in the proportion of seven to one; whilst they are much more common among the dwellers in Northern climates than in the more lethargic and ease-loving inhabitants of the South. The energy and activity of the Anglo-Saxon race especially predispose them to this disease.

Structure of an Aneurism.—The *sac* consists more or less evidently of a distension of all or part of the original walls of the vessel whilst it is small; but as the aneurism increases, the original structure is replaced by a mass of newly-formed fibrous tissue, due to a condensation and matting together of the surrounding structures, with or without an internal lining of laminated fibrin deposited on parts where the endothelium has disappeared. The *contents* of the sac depend on the character, age and size of the aneurism. Whilst still small and with a complete endothelial lining, it contains fluid blood; but as the tumour grows, and especially if of the sacculated type, fibrin is deposited in layers which gradually encroach on the cavity, and may in time completely fill it, so that in rare cases a spontaneous cure results. The oldest laminæ are dry and yellowish-white in colour; those more recently deposited are softer and more reddish, whilst the last formed is merely like ordinary blood coagulum No single lamina covers the whole area, but layer is arranged over layer (Fig. 100) in such a manner that the oldest and necessarily the smallest laminæ are nearest to the sac wall.

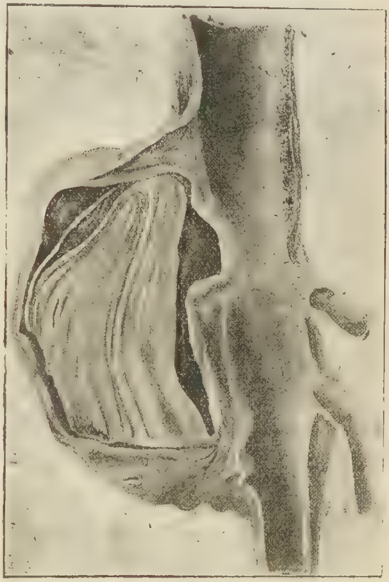

FIG. 100.—SACCULATED ANEURISM. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

The small mouth of the saccule is clearly seen, and the cavity is nearly filled with laminated clot.

Three chief **forms** of aneurism have been described: the fusiform, sacculated, and dissecting.

1. The **Fusiform Aneurism** (Fig. 101, A) is one in which the whole lumen of the vessel is more or less equally expanded, so that the swelling is tubular in character. It is generally due to a widely

extended disease of the arterial walls, and hence is more common in the larger internal vessels, such as the aorta, than in those of the extremities. The tunica intima is usually represented throughout the whole extent of the sac, but is thickened and atheromatous in patches, the margins and surfaces of calcareous plates being indicated by flocculi of fibrin, which are attached to them, although no regular laminated deposit may be present. The tunica media is stretched, atrophied, and in the later stages practically non-existent, whilst the adventitia is much thickened by inflammatory new formation and by incorporation with the surrounding tissues. The progress of fusiform aneurisms is generally slow, so that in some situations, *e.g.*, the thorax, they may attain enormous dimensions, and cause grave pressure symptoms. A natural cure is almost impossible, and hence, if unchecked by treatment, rupture of the sac is likely to occur, especially if, as often happens, one portion of the wall yields more rapidly than another, thereby inducing a localized sacculation.

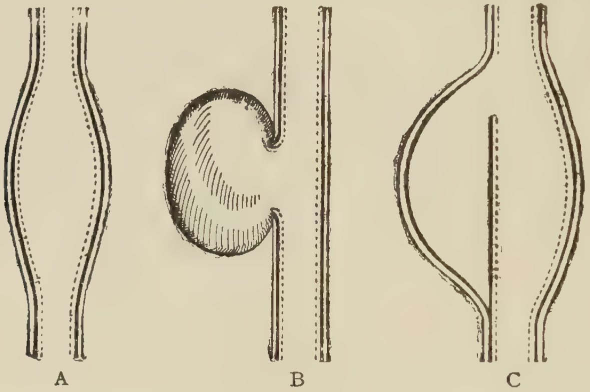

FIG. 101.—DIAGRAMS OF FUSIFORM, SACCULATED, AND DISSECTING ANEURISMS.

In the fusiform (A) the walls are expanded, but more or less normal in texture; in the sacculated (B) the normal structure of the arterial wall ceases abruptly at the commencement of the saccule; in the dissecting (C) the arterial wall is split into two lamellæ.

The interrupted fine line is supposed to represent the intima; the continuous dark line, the media; and the continuous fine line, the adventitia.

2. A **Sacculated Aneurism** (Figs. 100 and 101, B) is due to the yielding of some weak patch in the vessel wall which does not involve the whole circumference, or, as just mentioned, it may spring from a fusiform aneurism. It communicates with the interior of the artery by an opening of variable size. All traumatic aneurisms, whether due to the yielding of a cicatrix, or to the partial division of the coats of the vessel, are of this type, which is hence found most commonly in the extremities. The inner and middle coats can usually be traced

as far as the mouth of the saccule, but there they are suddenly lost, the wall being constituted by a mass of fibro-cicatricial tissue, upon which laminated fibrin readily forms, thus increasing its thickness and power of resistance. Their progress is, however, much more rapid than that of the fusiform, generally ending in rupture or diffusion, although occasionally a natural cure results.

3. A **Dissecting Aneurism** (Fig. 101, C) is one in which the blood forms a cavity within the wall of the vessel by stripping up the inner from the outer half, the line of cleavage being within the middle coat, half going with the adventitia, half with the intima. It is usually the result of extensively diffused atheroma. The blood thus driven into a cul-de-sac may remain limited to this cavity for some time, or it may find its way outwards and become diffused, or burst back through another atheromatous spot in the interior of the vessel. The condition occurs chiefly in the thoracic or abdominal aorta, but cannot be recognised *ante-mortem*.

Symptoms and Signs of a Circumscribed Aneurism.—These may be divided into two groups: the intrinsic and extrinsic.

Intrinsic Signs.—A tumour, pulsating synchronously with the heart's beat, is present in the course of a vessel. The pulsations are distensile or expansile in character, *i.e.*, the whole tumour increases in size at each systole, and that evenly in all directions, so that if the tumour is lightly grasped in any position the fingers are separated. A definite thrill can often be felt as the blood enters the sac at each heart-beat. If the supplying vessel is compressed on the proximal side, the pulsation ceases, and the tumour diminishes in size and becomes softer; this is more marked in fusiform than in sacculated aneurisms. The application of pressure to the sac itself, whilst the afferent trunk is compressed above, may still further diminish its size. On removing the pressure, the swelling regains its old dimensions in a certain definite number of beats, usually not more than two or three. Pressure on the distal side of the sac makes it more tense and the pulsation more marked, unless such compression is very prolonged. On auscultating the tumour, a bruit of variable character may be heard; usually it is loud, harsh, and systolic, but sometimes quiet and musical. It is occasionally double in some forms of sacculated aneurism, and in the aorta when regurgitation through the aortic valves is also present. The bruit is loudest and most rasping in the fusiform variety, and may be absent in the sacculated form, when the mouth is small and the cavity nearly full of clot.

The **Extrinsic Signs** of aneurism are those occurring in neighbouring or distal structures from its constantly increasing size and **pressure,** and the interference produced by it with the circulation. The *pulse* on the distal side is diminished and delayed, its diminution being caused partly by the obstruction experienced, but also in some cases by the pressure of the sac upon the trunk above or below the tumour. The delay is due to the interference with the transmission of the heart's impulse by the intervention of the aneurismal sac

The smaller vessels engaged in establishing collateral circulation may be compressed by the sac, and thus the vitality of the limb impaired. Pressure on the accompanying vein or *veins* results in diminution of their calibre, and possibly a localized thrombosis, together with distal congestion and œdema. Compression of *nerves* occasions neuralgia, spasm, or paralysis. *Muscles* are displaced, expanded, and attenuated; *bones* may be eroded, as evidenced by a deep, constant, boring pain, and even spontaneous fracture may ensue; whilst *joints* are encroached upon and disorganized. *Tubes*, such as the trachea or œsophagus, are often constricted and even laid open by ulceration. It is interesting to note that resisting tissues, like bone, are much more liable to be eroded than elastic, yielding structures, such as cartilage; where the vertebral column is encroached upon by an aneurism, the bones are always destroyed more than the intervertebral discs.

A certain amount of compensatory hypertrophy of the *heart* is often present. Fibrinous masses are occasionally set free as *emboli*, and lead either to a spontaneous cure, or to gangrene of the parts supplied by the vessel, or to death if the brain is involved. *Gangrene* may also result from the diminished blood-supply to peripheral parts; it is usually of the dry type, involving merely one or two fingers or toes, unless the veins are compressed, when it may be of the moist variety.

The **Differential Diagnosis** of a circumscribed aneurism is usually not difficult, but the following conditions may simulate it somewhat closely: 1. A *tumour* or *chronic abscess* situated near an artery, and deriving *transmitted pulsation* from it, is recognised by the impulse being merely heaving in character, and not expansile; by the pulsation ceasing entirely if the tumour is lifted from the vessel, or allowed to fall away from it by assuming a suitable position; by the size of the tumour not diminishing if the pulsation is stopped by pressure on the vessel above; and by the fact that after stoppage of the pulsation the first beat is equal to the subsequent ones, whereas in an aneurism it almost always requires more than one beat to re-establish the strength and force of the impulse. Moreover, the pulse below is not affected in the same way or to the same extent as when an aneurism is present. 2. An *artery* is sometimes *pushed forwards* by an underlying growth, and its pulsation in a more than usually superficial position may suggest an aneurism. The distinguishing features are the limitation of the pulsation to the line of the vessel, and the absence of pulsation in the underlying growth. 3. A *pulsating sarcoma* or *nævus* is known by being rarely limited exactly to the line of the artery, pulsation being present in situations where an aneurismal dilatation could not be felt, and being less forcible and regular in its character. The consistency of the swelling is more variable, and pressure over the afferent trunk does not diminish its size to any marked extent. Moreover, a sarcoma is usually more adherent to the deeper structures, and its limits are not so accurately defined. 4. The pain caused by an aneurism may lead it to be mistaken for *rheumatism or neuralgia* (*e.g.*, for sciatica in popliteal aneurism), and in every case of obstinate pain of this kind the arteries should always be carefully examined.

Natural Terminations and Results.—1. **Spontaneous Cure,** though very unusual, may occur in sacculated aneurisms. (*a*) It may be due to the *gradual* deposit within the sac of fibrin, which, in the first place, limits the expansion and extension of the aneurism, but may finally increase to such an extent as to occupy the whole cavity and close up its mouth. This condition can only obtain in saccules with small mouths, and in vessels of the second magnitude, hardly ever in the aorta or larger trunks, the impetus of the blood-stream being too great to permit of the necessary deposit of fibrin. (*b*) It may arise as the result of the *sudden* coagulation of all the blood in the sac from the stoppage of the circulation, owing to the lodgment of an embolus either at the mouth of the aneurism or in the trunk immediately below. (*c*) The aneurism may become so large as to compress the main vessel, either going to or coming from it, thus bringing about its own cure. (*d*) Again, if the sac becomes inflamed, consolidation may occur with or without suppuration, although the latter process, as will be seen anon, is attended with serious danger to life and limb.

The sac becomes more and more firm, the pulsation less forcible and distinct, the bruit diminishes, and finally consolidation is effected, a firm fibroid tumour alone remaining, which gradually shrinks, whilst the collateral circulation is opened up so as to supply the limb below. It is sometimes by no means easy to recognise the fibroid mass which results from a *consolidated aneurism*, and in making a diagnosis the history has mainly to be depended on. The existence of a tumour in the line of an artery, the probable occlusion of the main trunk, and the fact that the circulation is carried on by means of collateral branches, are the chief points which can be ascertained by a physical examination.

2. **Diffusion and Rupture** result from yielding of the walls of an aneurism, as an outcome of some mechanical injury or from simple over-distension.

When an **internal** aneurism gives way, the patient usually experiences a sensation of pain in the part, and becomes pale, cold, and faint, possibly dying within a few minutes or, at most, hours; or there may be a sudden gush of blood from the mouth if the trachea or œsophagus has been opened. Sometimes internal aneurisms leak slowly, and the final stage lasts some days.

When an **external** aneurism yields, it may do so slowly or quickly. If the blood becomes effused *slowly* (a *leaking* aneurism), the tumour gradually increases in size, and its outline is less clearly limited; the pulsation diminishes in force and distinctness, and the signs of pressure upon the veins or nerves become more urgent, until gangrene sometimes supervenes. If the sac yields *suddenly* (a *ruptured* aneurism), the patient experiences severe pain in the part which becomes tense, swollen, and brawny; all pulsation ceases, both in the aneurism and below it, and gangrene of the limb follows, or even death from syncope, if the skin gives way. Suppuration may also occur in these cases.

3. **Suppuration** is an exceedingly serious, but by no means a usual, complication. It may arise in the following ways: (*a*) After ligature of the main vessel, especially when the wound becomes infected, and there is a good deal of loose cellular tissue around the sac, as in the axilla; (*b*) after diffusion, partial or complete, of an aneurism, where there is great tension upon surrounding parts. Auto-infection or the presence of an infective embolus may finally determine the suppurative process. The tumour shows signs of inflammation, becoming hot, red, painful, and swollen, and the skin over it may pit on pressure; whilst fever and general constitutional disturbance are also present. Sooner or later, if left to itself, the tumour points at one spot and bursts, giving exit to a mixture of blood-clot, pus, and a greater or less amount of bright red blood. The patient either dies at once from syncope, or a little later from secondary hæmorrhage and toxæmia, unless efficient treatment is adopted. Occasionally, but very rarely, the afferent trunk becomes plugged by a thrombus, and spontaneous cure may thereby be induced.

Treatment of Aneurisms.

I. **General Treatment** is employed as an accessory to surgical measures, or must be depended on entirely in cases where local means are impracticable, as in internal aneurisms.

In *plethoric* individuals, where the disease often runs a rapid course, absolute rest, both mental and physical, must be enjoined, with the removal of all sources of irritation and worry. The bowels should be kept gently open, and constipation and straining avoided. The heart's impulse may be diminished by the use of aconite, or even by venesection when it is very forcible. Iodide of potassium is usually prescribed, on account of the frequent association of aneurism with syphilis; and calcium lactate (grs. 5, t.d.s.) may be useful in increasing the coagulability of the blood. The diet must be suitably diminished, and only highly nutritious material allowed, and that mainly of the nitrogenous type, with as little fluid as possible (not more than about a pint a day).

In *weakly individuals*, whilst strictly enjoining a recumbent posture, the surgeon should prescribe iron and a somewhat more liberal diet, in order to improve the quality of the blood.

II. **Surgical Treatment.**—A. The ideal plan consists in dealing with the arterial wall so as to obliterate the aneurism, but without occluding the original lumen of the vessel, according to the suggestion of Matas* of New Orleans. This is obviously only possible in selected cases of sacculated aneurism, but a number of satisfactory results have been reported. The circulation is controlled temporarily, and the aneurism laid freely open, so that its interior can be emptied completely and carefully examined. The orifices of the smaller collateral branches are secured by purse-string sutures, and the margins of the main opening are approximated by a row of Lembert's sutures, if need be, over a piece of rubber catheter, which is subsequently removed; the continuity of the original vessel being thus restored, the aneurismal walls are brought together by superimposed rows of Lembert's sutures. It is probable that in many instances the artery becomes obliterated in spite of the surgeon's care.

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* *Annals of Surgery*, February, 1903. Also Report of International Congress of Medicine, London, 1913, Section VII., part ii.

In unsuitable cases, *e.g.*, fusiform aneurisms, the surgeon may operate with the intention of obliterating the cavity of the sac. The openings of the main vessel, above and below, are first secured from within, as also any smaller branches, and then the cavity is obliterated by rows of stitches as before. In neither of these plans must the sac be detached from its surroundings.

B. **Complete Extirpation** of the aneurismal sac, as if it were a tumour, may be looked on as the best method of treatment in the majority of cases. The limb is exsanguinated by elevation, and in suitable cases the aneurism is removed without opening it, and the vessel secured by ligature above and below, as also any branches which may arise from it. Sometimes, however, it is necessary to open it and turn out its contents before attempting its extirpation, which is often a matter of considerable difficulty owing to the adhesions present. Not unfrequently the vein will be encroached on in this dissection, and it may have to be removed; bad results are not likely to follow, since the pressure of the sac has already probably established an efficient collateral venous circulation. The results of this operation are most satisfactory, since the length of treatment is curtailed, and all chances of local recurrence are removed. Gangrene also is uncommon, since only one set of collateral circulation is called upon, viz., that required to bridge the gap made by removing the aneurism, whereas in the Hunterian operation a double set is needed, viz., at the site of the ligature, and round the consolidated aneurism.

C. The **deposit within the sac of fibrin,** which shall subsequently organize and thus lead to the obliteration of both sac and supplying vessel, was the ideal aimed at by the earlier surgeons, and has still to be relied on in many cases. It is obvious that a slow and gradual deposit of laminated fibrin is likely to be more satisfactory than the sudden distension of the sac with soft red clot.

The various plans adopted with this end in view are as follows:

1. **Compression** of the main vessels, usually on the proximal side of the aneurism, was much vaunted by the Dublin school of surgeons in the last century, and gave not a few good results. It may be applied either continuously or at intervals. If *intermittent*, the main vessel leading to the aneurism is controlled by means of fingers (digital compression), or by mechanical contrivances (such as a tourniquet or a conical bag filled with shot), for as long a period as the patient can bear, which usually does not exceed thirty minutes, especially if there is any nerve in the immediate neighbourhood.

There seems to be no necessity to arrest completely the flow of blood through the sac, so long as the blood-pressure is sufficiently diminished to permit of coagulation within it. *Continuous* pressure under an anæsthetic aims at the entire stoppage of the circulation through the sac, so as to allow not only of its contraction, but also in some instances of the rapid coagulation of its contents. Such pressure may be effected by the fingers of relays of dressers, taking shifts of ten to fifteen minutes at a time. It is well to arrange for some weight, such as a conical shot-bag, to rest upon the thumb or finger employed, so as to relieve muscular strain.

Although in suitable cases compression may be given a trial before ligature, yet it is unwise to persevere with it for too long, especially in plethoric individuals with high arterial tension, if signs of improvement are not quickly observed, lest the collateral circulation be increased to an undesirable extent, and the success of the subsequent operation jeopardized. On the other hand, in feeble, weakly patients, where gangrene of the limb might be anticipated, the opening up of the collateral circulation by compression, even if the aneurism is not thereby cured, is by no means a disadvantage.

Necessarily, the skin to which pressure is applied must be protected from local irritation by shaving and removal of hairs, and the use of a dry aseptic dusting-powder, whilst the surface of any pad employed must be perfectly smooth.

2. **Ligature** of the main vessels leading to or coming from the aneurismal sac must next be considered. The oldest procedure, the **Operation of Antyllus,** consisted in laying open the sac, turning out the clots, securing the vessel above and below, and allowing the wound to heal by granulation (Fig. 102, A). Performed, as it was originally, without antiseptics, it was naturally attended with great mortality from secondary hæmorrhage.

In **Anel's Method** (Fig. 102, B) the artery was tied just above the sac on the cardiac side, with no branch intervening; this also proved dangerous, since secondary hæmorrhage frequently resulted, either from suppuration within the sac, or from injury to the sac during the operation, or from yielding of the arterial wall at the site of ligature from septic peri-arteritis. At the present time it is not unfrequently undertaken successfully.

Hunter's Operation (Fig. 102, C), which consists of ligature of the main vessel on the cardiac side at some distance from the aneurism, was first performed by him in 1785. The object is not to cut off absolutely the blood-supply to the sac, but to allow the blood to enter it with a greatly diminished impulse, and in small amount at first, thus permitting of the contraction of the sac wall and of the gradual deposit within it of fibrinous clot, which in time becomes organized into a mass of firm fibroid tissue. It is desirable, though not essential, that no branch of large size should intervene between the point of ligature and the sac. The operation is *contra-indicated* (1) in cases where serious cardiac disease co-exists, or when an internal aneurism is also present, rendering undesirable any sudden increase of the blood-pressure, as by occlusion of a main vessel; (2) where pressure over the vessel does not control the circulation through the sac; (3) where the peripheral vessels are extensively calcified; (4) where gangrene of the limb is threatening or present; or (5) where bones or joints have been seriously involved.

Distal Ligature is only practised for aneurisms situated in positions where it is impracticable to deal with the artery on the cardiac side of the sac, such as the innominate, lower part of the carotid, or first part of the subclavian. **Brasdor's Operation** consists in tying the main trunk beyond the sac, so as totally to cut off the circulation through it (Fig. 102, D). In **Wardrop's Operation** a ligature is placed on one or more of the distal branches (Fig. 102, E). In the former the sac gradually contracts, and thus allows of the deposit of fibrin; in the latter proceeding, where the circulation is only partly controlled, the diminution of the size of the aneurism goes on much more slowly, and the chances of the deposition of clot in the sac are correspondingly lessened.

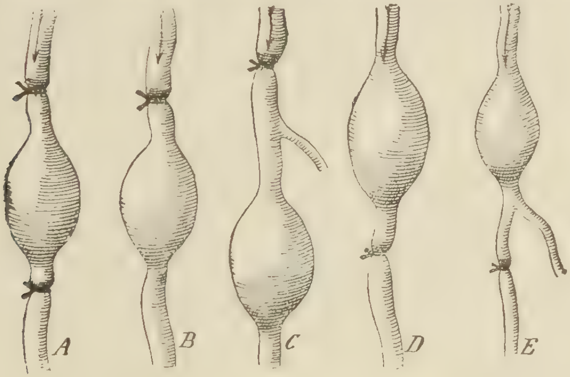

FIG. 102.—METHODS OF APPLYING LIGATURES FOR ANEURISMS

A, Method of Antyllus; *B*, Anel's operation; *C*, the Hunterian operation; *D*, Brasdor's operation; *E*, Wardrop's method.

It is not unusual, after the application of a ligature to a main artery for aneurism, to observe a **return of pulsation in the sac** after a day or two. In the majority of cases this only continues for a short time, and is by no means an unfavourable sign, indicating the re-establishment of the collateral circulation; but if it commences a week or ten days after the operation, it is more likely to persist. It is most frequently seen in cases where the main vessel has been tied at some distance from the sac, as in the superficial femoral for popliteal aneurism, and where one or more large and important collateral branches carry blood into the artery below the ligature or directly into the sac. The early recurrence of pulsation needs no *treatment* in most instances; but when it comes on at a later stage, it demands serious attention. Rest, elevation of the limb, and judicious pressure over the trunk above the site of ligature, should first be tried. These failing, the following courses are open: (*a*) The artery may be again tied, either nearer the sac when feasible, or further away from it; (*b*) where the aneurism can be reached, it may be cut down on and dissected out, the best course to adopt if it be practicable; or (*c*) amputation just above the aneurism may be called for as a last resource.

3. **The Introduction of Foreign Bodies into the Sac** (*Moore's Method*) has not been followed by much success, although a few cases of abdominal aneurism seemed to have derived temporary benefit from it. Steel wire has been usually employed; it is firmly wound round a cotton reel to give it a spiral coil, and inserted into the sac through a very fine cannula. Varying lengths from 10 feet to 26 yards have been introduced.

4. The combination of this last method with electrolysis (as originally suggested and practised by an Italian, Corradi, in 1879) has been attended by some very happy results, especially in the hands of Stewart of Philadelphia.* He introduces a variable length of gold or silver wire (No. 30 gauge), preferably the former, through a small cannula, and then performs electrolysis through the wire which is attached to the positive electrode, whilst the negative electrode is placed on the back. The current is gradually increased up to 60 or 80 milliampères, and the whole proceeding lasts about thirty minutes. Finally, the wire is cut short and the end pushed into the sac, and the opening ligatured. Several brilliant results have followed this plan of treatment, including the cure of an innominate aneurism, the patient living for three and a half years, and of an aneurism of the abdominal aorta, dealt with by transperitoneal operation.

An ingenious contrivance has been designed by Messrs. D'Arcy Power and Colt for this purpose. It consists of a fine wire wisp or cage, which can be introduced closed as a cartridge through a special cannula, and pushed by a ramrod into the sac, where it expands of itself umbrella-fashion, thereby exposing a large surface of wire on which coagulation can occur; it is also arranged for electrolysis. Satisfactory results have attended its employment.

D. Quite distinct in principle from the preceding plans is that associated with the name of Sir William Macewen, who looks on blood-clot as undesirable material to work with for the cure of an aneurism, and directs his attention to thickening the walls of the sac to such an extent as to determine its occlusion, or to prevent its subsequent dilatation. To this end he employs **Acupuncture,** introducing several fine needles into the sac and leaving them to be played upon for a time by the blood-stream, so as to scratch and irritate the further wall of the sac, and thus cause an inflammatory hyperplasia, which shall subsequently organize into dense fibro-cicatricial tissue. The process must be repeated as often as is considered necessary In his own hands excellent results have been obtained; but whilst admitting its value for internal aneurisms, we cannot but think that for those involving peripheral vessels other methods would be more rapid and equally effective.

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* *British Medical Journal*, August 14, 1897; *Philadelphia Medical Journal*, June 25, 1898.

E. **Amputation** may be required in the treatment of aneurisms under a variety of circumstances: (*a*) When extensive gangrene of the limb has occurred or is imminent; (*b*) for diffusion or suppuration of an aneurism when everything else has failed; (*c*) for secondary hæmorrhage as a last resource; (*d*) in some cases of recurrent aneurism: (*e*) when joints have been opened or bones eroded to such an extent as to impair the utility of the limb; and, finally, (*f*) in a few cases of subclavian aneurism amputation at the shoulder-joint has been practised in order to diminish the amount of blood flowing through the sac.

The Treatment of a Diffuse Aneurism varies somewhat according to whether the diffusion is slow or rapid. In a *leaking* aneurism the main vessel leading to the swelling must be tied, if this has not already been undertaken, and the influence of this measure, combined with rest, elevation, and careful general treatment, observed. Should the process not be stayed, the case is treated as a diffuse or *ruptured* aneurism by laying open the sac, after exsanguinating the limb by elevation and the use of an elastic band, and securing, if possible, the main vessel above and below, as also any branches which may open into the sac, if they can be found. If there is any evidence of incipient gangrene, or if secondary hæmorrhage supervenes, amputation must be undertaken. In such cases everything will depend on the efficient maintenance of asepsis.

The **Treatment of an Inflamed Aneurism** is always a matter of anxiety from the risk of recurrent and fatal hæmorrhage. If the main trunk has not been previously tied, this should at once be undertaken so as to reduce the blood-pressure in the sac, and the effect carefully watched; an ice-bag should also be applied to he part, and the limb elevated. If no good result follows, or if the artery has already been tied, nothing remains but to lay the sac freely upon and endeavour to secure, by ligature, the main trunk above and below, as well as any smaller branches. Unfortunately, the walls are often soft and rotten, so that ligatures cut out; should bleeding supervene, the cavity may be packed with gauze in the hope of checking it, and determining repair by granulation, but more often amputation will be required.

Special Aneurisms.

Aneurism of the Thoracic Aorta is most commonly of the fusiform type in the early stages, but a limited sacculation often supervenes as the disease advances. The symptoms vary with the part affected. (1) In the *ascending part of the arch* the swelling rarely reaches a great size, especially if it is intrapericardial, the sac usually rupturing before marked pressure signs are evident.

(2) When arising from the *transverse part of the arch*, the symptoms vary with the direction taken by the enlargement. If it projects

upwards, a pulsating tumour may appear at the episternal notch, and cerebral effects may then ensue from interference with the circulation through the carotids, or from pressure on the venous trunks. If it extends *anteriorly*, it may form a large pulsating tumour to the right of the sternum with comparatively slight pressure effects, except the pain arising from its erosion of the thoracic wall. If the enlargement takes place either *posteriorly* or *downwards* within the concavity of the arch, symptoms of dyspnœa and dysphagia are early produced from the close contiguity of the trachea, œsophagus, and pulmonary vessels. Pressure upon the left recurrent laryngeal nerve, as it passes round the aorta, results in spasm of the laryngeal muscles, especially of the crico-arytenoideus posticus, producing suffocative attacks of dyspnœa and a loud metallic or brassy cough, which is very characteristic. At a later date the nerve is paralyzed, and then the voice becomes affected, and the vocal cord fixed and immobile, but without serious dyspnœa. Laryngeal or tracheal stridor may be noticed in these cases, and a dragging down of the trachea synchronous with the heart's action (the so-called 'tracheal tug'). Radiographic examination is a valuable means of diagnosis, since the aneurism gives a dark shadow on the screen or plate.

(3) Aneurisms of the *descending arch* and *thoracic aorta* often attain considerable dimensions, and may project posteriorly to the left of the vertebral column, causing a pulsating swelling. The only prominent symptoms are pain, due to erosion of ribs or vertebræ, and interference with deglutition, which may be so great as to suggest the presence of an œsophageal constriction; in fact, before a bougie is passed in any case of dysphagia it is always advisable to make certain by radiography that an aneurism is not present. Auscultation in the left vertebral groove may also reveal the existence of a systolic bruit where such a condition exists.

Treatment. — Little can be done beyond ordinary medical measures, such as rest, diet, and the administration of iodide of potassium. When the aneurism has projected in front, the introduction of coils of iron wire or horsehair has been attempted, and in one or two cases with partial or temporary success; whilst Stewart's method of electrolysis and Macewen's plan of acupuncture have been used with some benefit for supposed cases of sacculated aneurism. Dyspnœa may be at times severe, but *tracheotomy* should never be undertaken, death seldom resulting from this cause.

Ligature of the right carotid and right subclavian, or of the left carotid alone, has been adopted in cases of aneurism of the ascending aorta or of the arch. A certain amount of improvement followed some of the operations, but it is quite possible that this was as much due to the enforced rest in bed as to the operation. Of course, if the lower end of the carotid is involved in the aneurismal swelling, distal ligature may do some good, as in a case of our own,* where the left carotid and subclavian were tied, with a short interval between the operations. The patient's condition improved greatly for a time, and she was able to return to work, but the aneurism finally burst into the left pleura about three years after the first operation.

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* *British Medical Journal*, December 3, 1898.

Innominate Aneurism is usually of the tubular variety, and frequently associated with a similar enlargement of the aorta. It presents a pulsating tumour behind the right sterno-clavicular articulation—*i.e.*, between the heads of origin of the sterno-mastoid—projecting either into the episternal notch or outwards into the subclavian triangle, and perhaps pushing the clavicle forwards. The *pulse* in both the right temporal and radial arteries is diminished; *œdema* of a brawny character of the right side of the head and neck, and of the right arm, is caused by pressure on the right innominate vein, whilst less commonly similar changes on the left side may follow compression of the left vein or of the superior vena cava; *pain* shooting into the neck and arm is often produced by implication of the brachial nerves; hyperæmia and sweating of the right side of the face with dilatation of the right pupil may result from irritation of the sympathetic trunk. *Dyspnœa* is induced by direct pressure on the trachea, which may be displaced or flattened, or by compression of the right recurrent laryngeal nerve. *Dysphagia* occurs from pressure on the œsophagus. The course of the case is slowly progressive, and death most commonly results from asphyxia or from rupture of the sac.

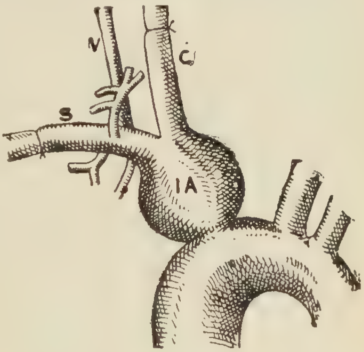

Fig. 103.—Application of Ligatures for Innominate Aneurism. (After Erichsen.)

IA, Innominate aneurism; S, subclavian artery; C, carotid; V, vertebral artery.

Treatment.—Rest and the administration of large doses of iodide of potassium may cause improvement, but distal ligature is the most hopeful proceeding. It is obviously impossible to cut off all the blood passing through the sac to the three main divisions—viz., the carotid, subclavian, and vertebral—with safety to the patient (Fig. 103). Ligature of any one of these by itself offers but little prospect of improvement, whilst tying both carotid and subclavian, with an interval of more than a week between the two operations, has practically the same effect as a single ligature, for by that time the collateral circulation will have been established. Simultaneous ligature is doubtless the best plan of treatment to adopt; it places the sac in the best possible condition for the deposit of fibrin, whilst the additional step of tying the third part of the subclavian does not add materially to the risk of the operation, which is mainly due to the effect on the cerebral circulation. Should these operative measures seem undesirable, recourse must be had to Stewart's or Macewen's method.

Aneurism of the Common Carotid is usually situated at the upper part of the trunk near the bifurcation, and more often on the right than on the left side. The root of the right carotid is also not unfrequently dilated, but the intrathoracic portion of the left carotid is rarely affected, except in conjunction with the aorta. No other external vessel is so frequently the seat of aneurism in women. The ordinary intrinsic *signs* of an aneurism are present, and the pressure symptoms are mainly referable to interference with the cerebral circulation, to irritation of the cervical sympathetic trunk, or to pressure upon the larynx, pharynx, or trachea. The progress of these cases is usually slow.

Diagnosis.—(1) *From similar disease at the root of the neck* the distinction is often made with difficulty, since either an aortic, innominate, or subclavian aneurism may push upwards so as to simulate it somewhat closely. Percussion and auscultation of the upper part of the chest, together with a careful investigation into the history of the case, and a digital examination of the limits of the pulsating mass, may suffice to determine the point. The *pressure effects* must also be carefully considered. 'Pressure on the left recurrent laryngeal nerve would distinguish an aortic aneurism from one on the right vessels; pressure on the right nerve in like manner excludes an aortic aneurism. Pressure on the left innominate vein indicates aortic aneurism rather than innominate; compression of the internal jugular or subclavian vein only points to carotid or subclavian aneurism. A "tracheal tug" indicates an aneurism of the aorta' (Pearce Gould). The differences in the *peripheral pulses* in the radial and temporal arteries may also give useful information. If the left radial pulse is alone aneurismal, the root of the left subclavian is diseased, whilst if the left temporal is also affected, it suggests an aneurism of the transverse part of the arch beyond the innominate. When both radial and temporal vessels on the right side show signs of interference with the pulse, innominate aneurism is probably present, whilst an affection of only one of these branches indicates that the corresponding carotid or subclavian is dilated. One source of fallacy must not be forgotten, viz., that any one of these trunks may be occluded or compressed by a neighbouring aneurism without being dilated, and hence the quality of the pulse must be taken into consideration rather than its actual volume, and to this end the sphygmograph is a useful adjunct in diagnosis. (2) From *abscess, tumours, or enlarged glands* with a transmitted impulse, a carotid aneurism is recognised by an application of the general principles detailed above (p. 312). (3) *Pulsating or cystic goitre* may be distinguished from a carotid aneurism by noting that the goitre is not as a rule limited to one side of the neck, the isthmus being also involved; that the most fixed part of the tumour is in the median line, and not under the sterno-mastoid muscle; and that the swelling moves up and down during deglutition, an aneurism remaining fixed. (4) An aneurism close to the bifurcation may be simulated by an *abnormal arrangement of the terminal branches*, the external carotid crossing the internal from behind forwards, and being pushed outwards sufficiently to cause a pulsating swelling beneath the skin. This condition is usually symmetrical, and can be recognised by careful palpation.

Treatment.—*Ligature* of the carotid above or below the omo-hyoid is the treatment usually adopted, and generally with great success If the aneurism is near the root of the neck, the distal operation (Brasdor's) must be undertaken.

Aneurism of the External Carotid is seldom met with, except as an extension of one involving the bifurcation. The usual phenomena are presented near the angle of the jaw, and well above the thyroid cartilage. Pressure results are early experienced, *e.g.*, paralysis of one side of the tongue through implication of the hypoglossal nerve, aphonia, or dysphagia. In suitable cases, the sac may be dissected out after securing the branches arising from it; failing this, the common trunk must be tied.

Aneurism of the Internal Carotid (extracranial portion) presents symptoms which closely resemble those caused by an aneurism of the bifurcation or of the external carotid, except that the swelling projects more into the pharynx, from which it is separated merely by the pharyngeal wall. It appears as a tense pulsating tumour, placed immediately under the mucous membrane, and looking dangerously like an abscess of the tonsil. The **Treatment** consists in tying the common carotid.

Intracranial Aneurism occurs more commonly upon the internal carotid and its branches than upon those arising from the vertebrals, although the basilar artery is more often affected than any other single vessel. The aneurisms are generally fusiform in character, and their origin is often obscure, being attributed to a blow or fall; in children they are stated to result from the lodgment of infected emboli. They sometimes cause no symptoms until the patient is suddenly seized with a rapidly fatal apoplexy from rupture of the sac. Symptoms, if present, are due rather to compression of the brain than to erosion of the more resistant bony structures. Pain which is more or less fixed and continuous may be complained of, or there may be a feeling of pulsation, or of opening and shutting the top of the skull. Sight, hearing, and other functions of the brain, may also be impaired, but physical changes in the eyes, such as optic neuritisor atrophy, are not induced, unless there is direct pressure on some part of the optic tract. Occasionally a loud whizzing bruit may be heard on auscultating the skull. The only **Treatment** possible, if a diagnosis can be established, is ligature of the internal carotid artery, and even this will be of little use if the basilar is affected.

Orbital Aneurism.—Protrusion of the eyeball, together with pulsation, which can be felt or even seen (pulsating exophthalmos), is always an indication that some vascular lesion is present within the orbit. (*a*) It is occasionally *congenital*, and then probably due to the presence of a deep cavernous angioma. (*b*) It is most frequently *traumatic* in origin, resulting from a penetrating wound, or a blow on the head, which may have caused a fracture of the base of the skull; in these the lesion present is generally an aneurismal varix between the internal carotid and the cavernous sinus. (*c*) It may be *non-traumatic*, and result from an aneurism of the ophthalmic artery, or from thrombosis of the cavernous sinus. The patient complains of intra-orbital pain and tension; the conjunctival and retinal vessels are distended, and a marked bruit may be present on auscultation. The movements of the eyeball are limited, vision is impaired, and the cornea may become opaque from exposure; finally, the whole globe may be disorganized. A marked mitigation of all symptoms usually follows compression of the carotid.

Diagnosis.—Sarcoma of the orbital wall may exhibit many of the characters of intra-orbital aneurism. Careful palpation will, however, generally demonstrate the existence of a definite tumour: the pulsation, moreover, is less marked, and the bruit less distinct. The distortion of the eyeball and ocular axis is often considerable in malignant tumours, but vision is not so early affected.

Treatment.—Ligature of the internal carotid is the only means which holds out any prospect of benefit, except in the congenital cases, where electrolysis has been very successful.

Subclavian Aneurism is most frequently seen in men, and particularly in those who carry weights on their shoulders; the right vessel is more often affected than the left. Any part of the artery may be involved, but the greatest dilatation naturally occurs in the third portion. A pulsating tumour develops in the subclavian triangle, which may project above the clavicle, but often extends backwards, outwards, and downwards, causing pressure effects upon the veins and nerves of the arm, and also hiccough by irritation of the phrenic. Occasionally it encroaches on the dome of the pleura and apex of the lung, and has been known to burst into the pleural cavity. It does not increase in size very rapidly, being surrounded by dense unyielding structures, and never compresses the trachea or œsophagus. No special difficulty presents itself in *diagnosis* as a rule, although in the early stages it may be somewhat simulated by a normal artery pushed forwards by an exostosis of the first rib, or by a supernumerary cervical rib.

The **Treatment** of subclavian aneurism is surrounded with difficulties, and the results hitherto obtained have been most unsatisfactory. *Extirpation* has been undertaken with success after turning up the middle third of the clavicle, as also Matas' operation, but the aneurism is seldom sufficiently limited to allow of these proceedings. Stewart's method of electrolysis, and needling the sac according to Macewen's method, have been adopted with occasional success, but cannot be relied on. *Ligature of the innominate trunk* suggests itself as the operation to be adopted for cure by the Hunterian method, and recent records would certainly encourage one to repeat it in any suitable case, combined with simultaneous ligature of the carotid, so as to avoid backflow of blood. *Ligature of the first part of the subclavian* is occasionally possible, and a few successful cases have now been reported, although the first nineteen cases in which it was attempted died.

As a last resource, the plan suggested by the late Sir William Fergusson may be followed, viz., *amputation at the shoulder-joint and distal ligature* as near the sac as possible. Distal ligature alone is usually unsuccessful, since the great bulk of the blood needed for the nutrition of the arm still passes through the sac, and there is no means of checking this except by the removal of the limb.

Axillary Aneurism is usually the result of falls on the outstretched arm, or injuries to the shoulder, such as fractures or dislocations, or of attempts to reduce them. A pulsating tumour develops, and its pressure causes pain, local and neuralgic, or œdema of the arm. When the upper part of the vessel is affected, the pulsation is felt immediately below the clavicle, and may project up into the neck, displacing the clavicle forwards; if placed lower down, the aneurism occupies the axilla. The progress of the case is often rapid, and the thoracic cavity may even be encroached on. **Treatment.**—Compression (digital) or ligature of the third part of the subclavian artery is required, but if the aneurismal sac extends under the clavicle, it may be necessary to secure the second part of the artery, due care being taken of the phrenic nerve.

Aneurisms of the brachial artery, or of any of the vessels of the forearm, require no special notice. They are almost invariably traumatic in origin, and should be treated by extirpation.

Abdominal Aneurism.—The abdominal aorta may become the seat of aneurism, either at the upper part near the cœliac axis, or at the bifurcation. A pulsating tumour is observed near the middle line, and either close to the umbilicus or in the epigastric notch; the pulsation is expansile in type, and remains the same in character whatever the position of the patient. Pain, localized in the back from erosion of the vertebræ, or neuralgic from pressure on the solar plexus or lumbar nerves, is the chief symptom, whilst œdema of the lower extremities may arise from compression of the vena cava. There may be some concurrent derangement of the intestinal functions. Occasionally aneurisms form independently on the splenic, hepatic, or mesenteric vessels. *Diagnosis.*—Many conditions give rise to epigastric pulsation. Cardiac pulsation may be felt in the epigastrium when the heart is dilated, but should be easily recognised; as also an impulse transmitted from the aorta through a collection of fæces or a cancerous growth. The examination of such a case, if need be under an anæsthetic, should be conducted not only in the dorsal decubitus, but also in the genu-pectoral position, so as to remove the weight of the viscera from the aorta, when the pulsation will cease or be much diminished. Radiography is of great service in the diagnosis of these cases.

Treatment.—Failing medical treatment by rest and diet, *compression* was formerly relied on, being applied either on the distal or proximal aspect of the sac. The method is, however, clumsy and liable to bruise the abdominal viscera. More recently treatment by needling the sac has been employed, and certainly in Macewen's hands at least one case has been brilliantly successful. There is also one instance on record where the introduction of wire into the sac, combined with electrolysis, cured an aneurism as large as an orange; the abdomen was opened, and electrolysis was maintained for thirty-seven minutes.

Iliac or **Inguinal Aneurism** arises from either the common or external iliac, or from the common femoral; it is frequently sacculated in type and lobulated in shape owing to the pressure of fascial or other structures. The symptoms are very typical, and diffusion is certain to ensue sooner or later. The **Diagnosis** cannot be well mistaken in the early stages, but later on, and specially when situated high in the iliac fossa, it may be difficult to distinguish from a pulsating sarcoma. **Treatment.**—*Extirpation* is, of course, the best plan to adopt if it be possible, but more frequently one must depend on proximal *ligature*. For an inguinal aneurism, the external iliac may be tied with every prospect of success. If the aneurism is situated higher, ligature of the common iliac may be undertaken (transperitoneal operation), or even of the aorta. The latter operation has been performed in ten instances, and in all a fatal result followed, although two patients lived thirty-nine and forty-eight days respectively. Failing any of these methods, *compression* of the aorta or common iliac may be employed.

Aneurisms of the Gluteal and Sciatic Arteries are usually traumatic in origin, and present as pulsating swellings in the buttock, the gluteal situated at the upper part of the sciatic notch, whilst the sciatic lies more deeply, and may be partly intrapelvic. Pain in the limb from pressure on the sciatic nerve is a prominent symptom, especially in the sciatic variety. The **Diagnosis** is by no means easy, especially from a pulsating sarcoma. **Treatment.**—When the diagnosis is established, transperitoneal ligature of the internal iliac artery should always be adopted. If the sac is laid open from the buttock as a result of a mistaken diagnosis, the old-fashioned plan of treatment must be followed, viz., to turn out the clots and secure the bleeding-points.

Femoral Aneurism is the title given to one forming in the course of the superficial femoral artery. It is not uncommonly tubular, and occurs almost invariably in males. **Treatment** consists either in extirpation, or ligature of the common or superficial femoral trunk.

Popliteal Aneurism occurs almost invariably in men, constituting a pulsating tumour in the ham, rendering the knee painful and stiff, and so much do the symptoms resemble those of chronic rheumatism that in every such case the popliteal space should be examined. The limb is usually kept semiflexed, and the aneurism often increases rapidly in size. If the main swelling is situated in front of the vessel, there is some likelihood of the knee-joint becoming implicated and neighbouring bones carious; when it extends posteriorly, diffusion is not uncommonly followed by gangrene, on account of the pressure exercised, not only upon the vein, but also upon the articular branches of the popliteal artery, which are most important factors in maintaining the collateral circulation. The **Diagnosis** has to be made from chronic enlargement and abscess of the popliteal glands, but in these there is less disturbance of the circulation in the foot; from bursal tumours, by their want of mobility and pulsation; or from solid tumours, *e.g.*, pulsating sarcoma of the femur or tibia, by attention to the general principles already enunciated. In a few instances spontaneous cure has resulted from the pressure of the sac upon the artery above.

Treatment.—Compression has been eminently successful in many of these cases. Ligature of the femoral artery at the apex of Scarpa's triangle is, however, the plan most commonly adopted, and with the greatest success. In cases where either of these methods has failed, or where the aneurism has become diffuse or recurred, extirpation of the sac is the best course to adopt.

Ligature of Vessels.

This operation is performed to arrest the flow of blood to the periphery, in order either to check hæmorrhage, or to promote the cure of an aneurism, or to diminish the rate of growth of some tumour, or to influence beneficially some peripheral organ by reducing its blood-supply, or as a preliminary to removing some vascular structure, such as the tongue.

Operation.—The artery is examined as far as is possible, so that a healthy portion may be selected for applying the ligature. The various structures (*rallying-points*) met with on the way to the artery are recognised, and drawn aside, if need be, so as to lay bare the sheath of the vessel, which is opened over the artery by a longitudinal incision about ¾ inch in length. The aneurism needle is inserted unarmed, and gently manipulated up and down, so as to free the vessel all round, a matter of no great difficulty if the sheath has been correctly opened and the arterial wall exposed. The ligature may then be passed through the eye of the needle, and carried round the vessel, tied in a direction exactly at right angles to the longitudinal axis; in doing so the artery must not be dragged out of its sheath, but the ligature should be tightened by the tips of the forefingers meeting upon it. The opening in the sheath should be closed over the ligature by a fine buried stitch, and the various structures displaced in reaching the vessel are similarly secured in good position.

Method of Application of the Ligature.—In the smaller vessels and those of medium size all that is needed for security is a **reef** knot tied firmly; but in the largest trunks—*e.g.*, the innominate, first part of the subclavian, and common iliac—it is advisable to employ what is termed the **stay knot** (Fig. 104). Two strands of ligature are passed round the vessel side by side and half-knotted; the two ends on each side are then taken up together and tied across in one knot. The degree of tension used in these cases is such as to approximate completely the vessel walls, but without rupturing the inner or middle coats, thereby minimizing the risks of secondary hæmorrhage. Broad strands of animal ligature—*e.g.*, gold-beater's skin or ox aorta—should be employed in these cases.

Some surgeons recommend that two ligatures should be applied to the artery, and the vessel divided between them. This plan is suggested to avoid longitudinal traction on the site of ligature, which necessarily results from the fact that all arteries in the body are maintained more or less upon the stretch, as evidenced by their retraction when divided; it is supposed that secondary hæmorrhage is predisposed to by this condition. With modern aseptic methods this precaution is of little significance.

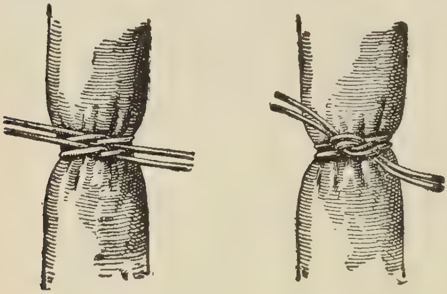

FIG. 104.—STAY KNOT.

The rule usually followed is to pass the needle *from important structures, such as the vein*, but really this is a matter of little importance when the above directions have been carefully carried out, and especially in superficial vessels. *Should the vein be accidentally punctured*, the needle must be at once withdrawn, and the puncture in the vein secured by ligature, whilst the artery is tied a little higher or lower. In dealing, however, with the smaller vessels, where the venæ comites are in close contact with the arteries, no harm will attend their inclusion in the ligature.

After-Treatment.—The patient must be kept at rest for at least three weeks in order to secure permanent obliteration of the artery and the effective development of a collateral circulation, especially in dealing with the larger vessels and in elderly people. When the main artery to one of the extremities has been tied, the limb should be wrapped in aseptic wool and slightly raised, and if there is any likelihood of gangrene, it should be thoroughly purified.

There are two great **dangers** liable to follow the ligation of an artery in its continuity:

1. **Secondary Hæmorrhage** (*vide* p. 293).

2. **Gangrene** may arise from a variety of causes: (*a*) From simple loss of vitality, owing to a defective collateral circulation, as when the peripheral vessels are calcareous and rigid. The tissues which receive the smallest amount of blood die first, *e.g.*, the fingers or toes, or the subcortical white substance of the brain. Severe loss of blood after the operation, as from secondary hæmorrhage, may also deter

mine tissue necrosis. Under such circumstances it almost always takes on the dry form. (*b*) Interference with the venous return, as by injury to the vein during operation, or the pressure of a tight bandage, or thrombosis induced subsequently by infective periphlebitis, is very likely to cause gangrene, and then it is of the moist type. (*c*) Unsuitable after-treatment, such as too great elevation of the limb, the injudicious application of an ice-bag or hot-water bottle during the period of diminished vitality immediately following the operation, or even an attack of erysipelas, may also bring about the death of some of the tissues. The **Treatment** of aseptic gangrene following ligature is expectant in character, the parts being allowed to separate naturally. But if there is much pain, or any tendency to spread, or if infection is present, giving rise to fever and general disturbance, it is wiser to remove the limb well above the line of demarcation.

The **Innominate Artery** has now been tied with success on at least six occasions out of a total of about thirty operations. An incision is made along the lower third of the anterior border of the sterno-mastoid, and is prolonged downwards to sweep over the upper edge of the episternal notch. The platysma and the superficial and deep fasciæ are divided, and the anterior jugular vein secured if necessary between two ligatures; the sterno-mastoid is drawn outwards, and its inner tendinous fibres are divided, whilst the sterno-hyoid and -thyroid muscles are severed close to the sternum and drawn inwards. The carotid sheath is now laid bare and opened at its lower part, so as to expose the carotid artery and enable it to be tied, and by following this downwards the innominate trunk is reached. In some cases it may expedite matters to remove portions of the sternum and inner end of the clavicle. The right internal jugular and innominate veins lie to the outer side of the artery, but if much engorged may project over it, and must then be drawn aside by retractors, whilst the inferior thyroid plexus may course directly downwards to reach the left innominate vein, which crosses the vessel. To the outer or right side and behind the veins are placed the vagus nerve and pleural sac, and these must be carefully separated from the artery, whilst the needle is passed from without inwards, and from below upwards. A double-curved aneurism needle will probably be required to effect this. A broad animal ligature should be used for this vessel, and the inner and middle coats must not be divided.

Collateral Circulation.—Intracranial : Vertebrals and carotids in the circle of Willis.

Face and Neck : Branches of the two external carotids across middle line.

Trunk : First aortic intercostal *with* superior intercostal of subclavian; upper aortic intercostals *with* thoracic branches of axillary and intercostals of internal mammary; deep epigastric and phrenic *with* terminal divisions of internal mammary.

The **Carotid Artery** may be tied either above or below the level at which it is crossed by the anterior belly of the omo-hyoid. The line of the vessel is indicated by that drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process, the bifurcation being on a level with the upper border of the thyroid cartilage.

Ligature above the Omo-hyoid.—The vessel is here more superficial, and the ligature is applied on a level with the cricoid cartilage. The patient lies upon the back, with the chin raised and the head turned towards the opposite side. A 3-inch incision is made in the line of the vessel, the centre on a level with the cricoid (Fig. 105, D). The skin, platysma, and fasciæ are divided, and the anterior edge of the sterno-mastoid defined. The deep fascia is incised along its inner border, so that it may be drawn aside by a retractor; the sterno-mastoid branch of the superior thyroid artery may be divided at this stage. On the inner side of the wound the omo-hyoid muscle must now be looked for, trending forwards and upwards from under cover of the sterno-mastoid. In the angle formed by these two structures the pulsation of the vessel should be felt and the sheath readily recognised, with the descendens cervicis nerve upon it. It is opened on the inner side, and the artery well cleared. The needle is passed from without inwards, and if the sheath has been efficiently opened, the vagus nerve will run no risk of being included.

Ligature below the Omo-hyoid.—A similar incision is made, but lower in the neck, reaching from the cricoid cartilage nearly to the sterno-clavicular joint. The sterno-mastoid is drawn outwards, and perhaps the anterior fibres may need to be divided; the sterno-hyoid and -thyroid muscles are retracted inwards or divided, and the omo-hyoid can usually be drawn upwards. The sheath is thus exposed, and opened on the inner side, the needle being passed as in the previous operation. It must be remembered that both internal jugular veins are directed towards the right side in the lower part of their course, and hence the left vein is likely to lie somewhat in front of the artery. The inferior thyroid veins may also be seen, and need to be drawn aside or ligatured.

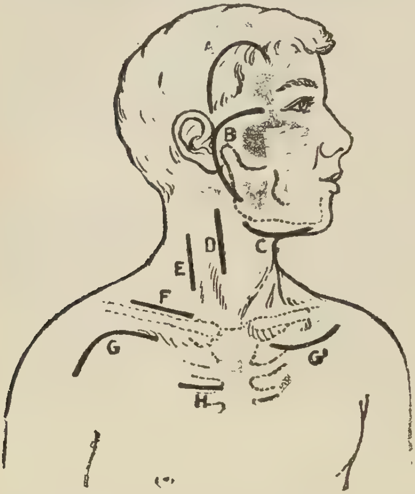

FIG. 105.—INCISIONS FOR VARIOUS OPERATIONS ON HEAD AND NECK.

A, Flap incision used in trephining for meningeal hæmorrhage; B, flap incision for operation on roots of the fifth nerve; C, incision for ligature of lingual artery; D, for ligature of common carotid; E, for ligature of vertebral artery; F, for ligature of the third part of the subclavian; G and G^{1}, incisions used for tying first part of axillary; H, for ligature of internal mammary artery.

The *effects* of ligature of the carotid upon the brain are of great interest and importance. Statistics prove that about 25 per cent. of the patients develop cerebral symptoms, either immediately in the form of syncope from cerebral anæmia, or in the course of a few days from cerebral softening, causing hemiplegia. A fatal issue is likely to result in about half the cases thus affected.

Collateral Circulation. — *Intracranial :* Circle of Willis.

Extracranial : Communications across the middle line of branches of the external carotids and vertebrals; inferior thyroid *with* the superior thyroid; profunda cervicis *with* princeps cervicis of occipital ; superficial cervical *with* branches of occipital and vertebral.

Ligature of the Internal Carotid.—An incision is made along the anterior border of the sterno-mastoid, its centre being opposite the great cornu of the hyoid bone; the muscle is pulled backwards, and the posterior belly of the digastric is seen and drawn up. The external carotid is displaced forwards, and then the internal carotid in its sheath appears. The latter is opened, and the aneurism needle passed from the jugular vein.

The *Collateral Circulation* to the brain is maintained by the circle of Willis.

Ligature of the External Carotid is occasionally required, the site of election being between the superior thyroid and lingual branches. An incision is made along the anterior border of the sterno-mastoid, 3 inches in length, its centre corresponding to the great cornu of the hyoid bone. The edge of the muscle is defined and drawn outwards, and the posterior belly of the digastric sought for above, the hypoglossal nerve lying just below it. The sheath is now opened below the tip of the great cornu, and the needle passed from without inwards. The operation may be rendered difficult by the presence of enlarged glands or veins, especially the lingual, facial, and superior thyroid, which lie in front of the vessel. The superior laryngeal nerve is placed immediately behind it, and must be avoided.

Collateral Circulation.—*Vide* ligature of the common carotid (extra-cranial portion).

Ligature of the Lingual Artery is chiefly employed as a preliminary to removal of the tongue for malignant disease. The vessel can be secured either close to its origin from the external carotid, or in the submaxillary triangle under cover of the hyoglossus muscle.

In the Submaxillary Triangle.—The patient lies on his back, with the shoulders raised, and the head extended backwards and turned to the opposite

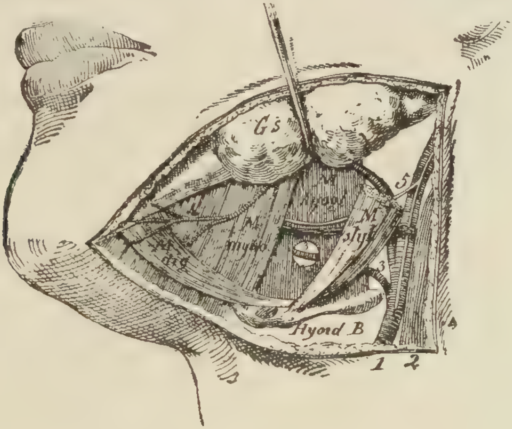

FIG. 106.—LIGATURE OF LINGUAL ARTERY. (TILLMANNS.)

The submaxillary gland (*Gs*) has been drawn over the side of the jaw with a hook; 1, external carotid; 2, internal jugular artery; 3, lingual artery; 4, ranine branch of facial artery; 5, hypoglossal nerve; *M dig*, digastric; *M styl*, stylo-hyoid; *M myho*, mylo-hoid; *M hyogl*, hyoglossus. The place where the artery is tied is indicated by a window in the hyoglossus, through which it can be seen.

side. A crescentic incision with its convexity downwards is made, commencing about 1 inch below the symphysis menti, and extending back to the sterno-mastoid, the centre opposite the great cornu of the hyoid bone (Fig. 105, C). The integument and platysma are divided, the lower border of the submaxillary gland is defined, and along it the deep fascia is incised. The gland is now drawn upwards and held over the margin of the jaw with a retractor (Fig. 106, *Gs*). On opening up the wound thoroughly the two bellies of the digastric muscle (*M dig*) are seen converging to the hyoid bone, the anterior belly passing superficial to the fibres of the mylo-hyoid muscle (*M myho*), which course nearly transversely to the mandible, and of which the posterior fibres may be divided with advantage. The digastric tendon is drawn down with a blunt hook, and in the space thus cleared the hyoglossus muscle (*M hyogl*) becomes evident with its fibres passing vertically upwards, and resting upon it the hypoglossal nerve (5) coursing forwards to get under cover of the mylo-hyoid, and either above or below it the ranine vein. The fibres of the hyoglossus are now divided transversely midway between the nerve and the hyoid bone, and in the opening made by their retraction is seen the artery (3), lying on the middle constrictor. Should it not be found in this situation, the incision in the hyoglossus should be extended backwards, and the vessel will then usually come in sight.

In the Neck Close to its Origin —An incision is made along the anterior border of the sterno-mastoid similar to that needed for ligature of the external carotid. The muscle is drawn backwards, and the great cornu of the hyoid bone defined. The small space is now cleared between that bony process and the posterior belly of the digastric, in which the artery can be felt resting upon the middle constrictor, and secured just as it rises from the external carotid.

The **Facial Artery** may be exposed and tied through a horizontal incision, 1 inch in length, made directly over the vessel as it crosses the lower border of the jaw immediately in front of the masseter.

The **Temporal Artery** is reached in front of the auditory meatus through a vertical incision, and must be carefully isolated from the auriculo-temporal nerve.

The **Occipital Artery** is tied through an incision extending from the apex of the mastoid process backwards for about 2 inches towards the occipital protuberance. The posterior fibres of the sterno-mastoid, the splenius, and trachelo-mastoid, are divided so as to expose the artery as it emerges from the groove on the under surface of the mastoid process, where it is easily secured.

The **Subclavian Artery** has been tied in each part of its course, but most frequently in the third. Ligatures of the first and second parts are such unusual proceedings that we must refer students to larger textbooks for descriptions.

For *Ligature of the third part* the patient is placed on the back, close to the edge of the table; the arm is well depressed, and the head turned to the opposite side. The skin is drawn down by the left hand, and an incision 3 or 4 inches long made over the clavicle (Fig. 105, F). On releasing the skin it retracts upwards, so that the wound comes to be situated about ½ inch above the clavicle, and thus the external jugular vein is more efficiently protected. The incision should be placed with its centre about 1 inch to the inner side of the middle of the clavicle, and should expose the space between the sterno-mastoid and trapezius muscles, the fibres of which are divided to a suitable extent if they encroach abnormally upon the bone. The external jugular and other veins often give the surgeon much trouble; they are either drawn aside or, if necessary, divided between ligatures. The deep fascia is incised in the line of the wound, care being taken to avoid the transverse cervical and suprascapular arteries, the former of which is above the line of operation, whilst the latter is hidden behind the clavicle. The posterior belly of the omo-hyoid, if seen at all, is drawn upwards. Various layers of fascia must be carefully cut or torn through until the nerves of the brachial plexus appear; the finger can then readily define the scalene tubercle on the first rib. The subclavian vein is situated in front of the finger, but on a lower level, whilst the artery itself can be detected pulsating under the pulp of the finger between it and the rib. The cords of the brachial plexus are placed above and external to it, the lower cord passing down behind. The needle is insinuated from above downwards and must be kept very close to the artery to prevent all possibility of including the lowest cord of the plexus. The operation in a thin patient may be easy, but in a stout subject, with a short thick neck and high clavicle, the greatest difficulty may be experienced in finding the vessel. The chief dangers arise from wounding the pleural cavity, or the superficial veins, or from ligaturing one of the cords of the brachial plexus.

Collateral Circulation.—Thoracic set : Branches of the aortic intercostals and internal mammary *with* thoracic branches of axillary.

Scapular set : Suprascapular and posterior scapular *with* subscapular and its dorsalis branch in the venter or on the dorsum of scapula.

Acromial set : Suprascapular *with* acromio-thoracic.

The **Internal Mammary Artery** (Fig. 105, H) may be exposed and tied by dividing the intercostal aponeurosis and muscles for an inch or more from the outer edge of the sternum, from which it is distant about ½ inch.

Ligature of the Vertebral Artery has been undertaken for wounds, for secondary hæmorrhage after ligature of the innominate, and in the treatment of epilepsy, but without much permanent benefit in the last case. An incision is made along the lower half of the posterior border of the sterno-mastoid (Fig. 105, E), the platysma and deep fascia are divided, and the muscle drawn forwards. The scalenus anticus is clearly defined, together with the phrenic nerve. The interval between it and the longus colli muscle can now be demonstrated, with the ascending cervical artery lying upon it. The anterior transverse process of the sixth cervical vertebra must be made out. Just below this the vertebral vessels are found entering the canal in the transverse process, and the vein, which is placed anteriorly, is drawn outwards to allow the needle to be passed from without inwards. A few sympathetic twigs are often included in the ligature, and may cause contraction of the pupil.

Ligature of the Thyroid Vessels is sometimes used as a means of arresting the growth of a goitre.

The *superior thyroid artery* is tied through an incision along the anterior margin of the sterno-mastoid, which has its centre opposite the upper border of the thyroid cartilage; the external carotid is defined, and the superior thyroid secured at its origin.

The *inferior thyroid artery* is reached through an incision along the inner border of the sterno-mastoid, extending upwards from the clavicle for 3 inches This muscle and the subjacent carotid sheath are drawn outwards, the sterno-hyoid and -thyroid usually needing to be divided. The transverse process of the sixth cervical vertebra is sought for, and the vessel found passing inwards immediately below. It is taken up just behind the carotid, and as far from the recurrent laryngeal nerve as possible.

The **Axillary Artery** is tied for punctured wounds of the axilla, as a distal operation for subclavian aneurism, occasionally for wounds of the palmar arch, and possibly for secondary hæmorrhage from the brachial. Two classical operations are described and practised in classes on operative surgery.

1. *Ligature of the first part of the vessel* is usually undertaken through a curved incision, with its concavity upwards, extending from the coracoid process to just below the sterno-clavicular joint (Fig. 105, G¹). The clavicular origin of the pectoralis major is divided, and the costo-coracoid membrane exposed and divided. Branches of the acromio-thoracic axis are displaced, and the main trunk is exposed by a blunt dissector and forceps. The vein lies within and below, and the cords of the brachial plexus above and to the outer side. The divided muscular fibres should be subsequently sutured together.

An incision which gives an unusually good approach and involves less division of muscular fibres is one which follows the lower border of the clavicle from its centre outwards to the coracoid process, and then turns down to lie over the interspace between the pectoralis major and deltoid muscles (Fig. 105, G). This intersection is opened up and the outermost fibres of the pectoralis which arise from the clavicle are divided. The costo-coracoid membrane is thus exposed, and the cephalic vein will act as a guide to the vessels.

2. *Ligature of the third part of the artery* is performed from the axilla. The arm is fully abducted, and the surgeon stands between it and the body. An incision is made in the course of the vessel (Fig. 107, A). The inner border of the coraco-brachialis muscle is clearly defined, and drawn slightly outwards, and the median nerve, together with the musculo-cutaneous trunk, at once comes into view. On drawing these inwards, the artery itself is seen, with the vein to the inner side. The needle is passed from the vein.

Collateral Circulation.—If above the acromio-thoracic, the same as for the third part of the subclavian (*q.v.*).

If above the subscapular and circumflex: Long thoracic and intercostals *with* thoracic branches of subscapular; suprascapular and posterior scapular *with* scapular branches of subscapular; suprascapular and acromio-thoracic *with* posterior circumflex in the deltoid.

If below the circumflex, same as for ligature of brachial above the superior profunda—*i.e.*, posterior circumflex *with* superior profunda in the deltoid.

The **Brachial Artery** may need to be ligatured for hæmorrhage from the palmar arches, or from a wound in the forearm or about the elbow, for aneurisms, or for arterio-venous wounds at the bend of the elbow. It may be tied in one of two places:

1. *At the Middle of the Arm.*—The arm is held away from the side at a right angle, with the hand supine, but with no support beneath it, for fear of pushing forwards the triceps and displacing the vessel. The surgeon stands between the arm and the trunk. An incision 2 inches long is made in the line of the vessel along the inner border of the biceps muscle (Fig. 107, B), and the thin fascial investment of the limb divided. The inner edge of the muscle is clearly exposed, and by drawing it slightly forwards the median nerve is brought into view, and perhaps the basilic vein. The nerve, which is at this spot crossing the artery from without inwards, is drawn inwards, and the sheath of the vessel found beneath it. The artery is separated from its venæ comites, and the ligature passed and tied.

The operation is by no means always easy, as there are many traps into which the beginner may fall. Thus the median nerve may cross behind the vessel instead of in front of it; the basilic vein may lie over its situation, and be mistaken for it; or there may be a high division, the two trunks usually lying close together. The most common mistake consists in not defining the biceps muscle, and in seeking for the artery behind its proper situation.

2. *At the Bend of the Elbow.*—An oblique incision is made, about 2 inches long, parallel to the inner border of the biceps tendon, its lower end corresponding to the crease of the elbow (Fig. 107, C). The incision should be placed at an angle of forty-five degrees to the axis of the limb, and to the outside of, and nearly parallel to, the median basilic vein, which, if seen, must be drawn inwards. The bicipital fascia is now incised, and the artery with its venæ comites exposed in the loose fat, the median nerve being well away on the inner side.

Collateral Circulation.—If above the origin of the superior profunda, posterior circumflex in deltoid *with* ascending branches of superior profunda.

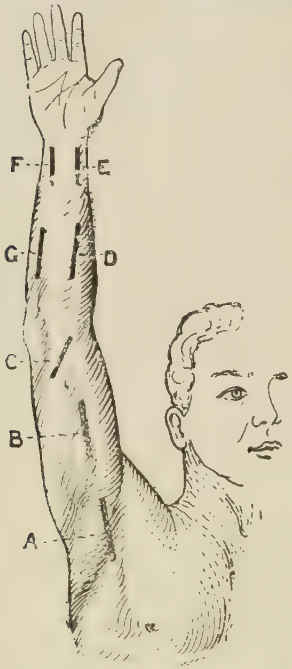

FIG. 107.—INCISIONS FOR TYING THE ARTERIES OF THE ARM.

A, Third part of the axillary; B, brachial; C, brachial at the bend of the elbow; D, middle third of radial; G, middle third of ulnar; E and F, lower thirds of radial and ulnar.

If below the origin of the inferior profunda, the anastomoses around the elbow-joint.

The **Ulnar Artery** rarely needs ligature except for palmar hæmorrhage or direct wounds. In the former case the artery can easily be secured just above the wrist, in the latter case, by enlarging the original wound. Various stereotyped operations are described, but are more often seen in the examination-room or dead-house than in the operating theatre. It should be borne in mind that the artery curves inwards from the centre of the bend of the elbow to the radial side of the pisiform bone. The lower two-thirds of its course is indicated by a line drawn from the internal condyle of the humerus to the same spot below.

1. *At the Wrist.*—An incision about 1 inch in length is made directly upwards from the flexure of the wrist in the line of the vessel (Fig. 107, F). The deep fascia is opened, the tendon of the flexor carpi ulnaris drawn to the inner side, and the vessels are then seen, accompanied by the nerve which lies to the ulnar side of the artery.

2. *In the Middle of the Forearm.*—An incision is made along a line drawn from the anterior edge of the tip of the inner condyle to the radial side of the pisiform bone (Fig. 107, G). The white line indicating the intermuscular septum between the flexor carpi ulnaris and flexor sublimis digitorum is then sought for and opened up; it is often very slightly marked, and may be difficult to distinguish. If the correct interspace has been opened, the surgeon is directed towards the ulna, and readily finds the vessels under cover of the flexor carpi ulnaris, with the nerve lying a little way to the inner or ulnar side.

3. The upper limit of the ulnar artery can be reached through an oblique incision along the upper border of the pronator teres, thus opening up the antecubital fossa, and exposing the bifurcation of the brachial.

Radial Artery.—The line of the vessel extends from the middle of the bend of the elbow to the interspace at the wrist between the flexor carpi radialis and the supinator longus. It then turns outwards, and may be felt beating in the space described by French anatomists as 'la tabatière' (or snuff-box), between the tendons of the extensor primi and extensor secundi internodii muscles.

1. *At the Back of the Wrist* the vessel may be secured by opening up the above-mentioned intertendinous hollow, where the artery is found coursing onwards to the base of the first interosseous space. The incision is placed obliquely between the tendons, extending from the back of the styloid process of the radius to the base of the first metacarpal bone.

2. *Above the Wrist* an incision is made in the line of the vessel (Fig. 107, E), which is found after division of the fascia between the supinator longus, and flexor carpi radialis.

3. *In the Middle or Upper Third of the Forearm* an incision is made in the line of the vessel (Fig. 107, D), and the inner border of the supinator longus sought for and retracted. The vessels are found under cover of this structure, with the radial nerve to the outer side, though separated by an interval above.

Ligature of the Abdominal Aorta* has been undertaken in fourteen instances for severe primary or secondary hæmorrhage, or for diffuse inguinal or iliac aneurism, when no other method of treatment was practicable. All these cases have proved fatal, in most instances from infection and secondary hæmorrhage. The operation consists in opening the abdomen through an incision slightly to the left of the middle line, having the umbilicus on a level with its centre. The intestines are retracted, and the posterior layer of the serous membrane covering the aorta carefully divided; there is then no difficulty in passing a ligature around the vessel. Possibly it would be well to prevent excessive backflow of blood by securing one or both of the common iliac trunks in addition; such would in no way interfere with the collateral circulation.

The **Common Iliac Artery** extends for a distance of 2 inches from the bifurcation of the aorta opposite the left side of the body of the fourth lumbar vertebra to the front of the sacro-iliac synchondrosis. It may be reached through an incision made in the median line with its centre a little below the umbilicus. The vessel is sought for and exposed by an incision through the posterior layer of the parietal peritoneum, and a ligature passed and tied. The ureter which crosses the artery just above its bifurcation must be carefully avoided.

Collateral Circulation.—Blood reaches the *external iliac* and its branches by means of the anastomosis of the lumbar arteries *with* the circumflex iliac, and of the superior epigastric, lumbars, and intercostals *with* the superficial and deep epigastric. The *internal iliac* and its branches are supplied by the union of (*a*) the lumbar branches *with* the ilio-lumbar; (*b*) the middle sacral *with* the lateral sacral; (*c*) the retropubic anastomosis of the two obturator arteries; and (*d*) the communications of the pudic, hæmorrhoidal, and vesical trunks *with* those of the opposite side.

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* See *Tillaux* and *Riche*, *Revue de Chirurgie*, January, February, and March, 1901.

Ligature of the Internal Iliac Artery is occasionally performed for hæmorrhage from, or aneurism of, one of its branches, the gluteal being that most commonly affected. The trunk is a short one, at most 1½ inches in length, and is best reached by opening the abdomen in the middle line below the umbilicus (Fig. 108, C), pushing aside the intestines, and searching for the bifurcation of the common iliac. The posterior layer of the peritoneum is then carefully incised, the ureter avoided, and an armed aneurism needle passed without wounding the vein.

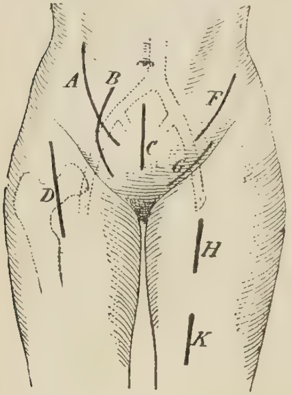

FIG. 108. — INCISIONS FOR OPERATIONS ON LOWER PART OF ABDOMEN AND UPPER PART OF THIGHS.

A, Mott's incision for retroperitoneal ligature of common iliac artery; *B*, Marcellin Duval's incision for the same; *C*, incision for transperitoneal ligature of internal iliac artery; *D*, incision for excision of hip by the anterior method; *F*, Abernethy's modified operation for ligature of external iliac; *G*, Astley Cooper's incision for same; *H*, ligature of femoral artery at apex of Scarpa's triangle; *K*, ligature of femoral artery in Hunter's canal.

The *Collateral Circulation* is the same as that given for the internal iliac division of the common iliac.

The **External Iliac Artery** is easily accessible in any part of its course, which measures from 3½ to 4 inches in length; it has but few branches, and those situated low down. Its position is indicated by the lower two-thirds of a line drawn from the bifurcation of the aorta to midway between the anterior superior spine and the symphysis pubis—*i.e.*, to a point a little internal to the middle of Poupart's ligament.

Many suggestions as to the best means of reaching the artery have been made, and both trans- and extra-peritoneal methods have been adopted. It is so readily secured, however, by the latter that it seems unnecessary to open the peritoneum. There are two chief forms of extraperitoneal operation.

Astley Cooper's Operation.—An incision is made parallel to the outer half of Poupart's ligament, commencing a little to the inner side of its centre, and ⅜ inch above it, and extending upwards and outwards to about 1 inch internal to the anterior superior spine (Fig. 108, G). The external oblique aponeurosis is divided along this line, and the exposed lower margins of the internal oblique and transversalis muscles arching over the inguinal canal are drawn upwards by retractors. The transversalis fascia and loose subperitoneal fat are now opened with forceps and director, and the vessel is felt pulsating immediately under the finger. The epigastric and circumflex iliac arteries must not be damaged during this manipulation, since they are important factors in the collateral circulation. The needle is passed from within outwards, the ligature tied, and the divided muscular and aponeurotic structures united by buried sutures.

Abernethy's Modified Operation is more commonly utilized. The incision, about 4 inches in length, extends from a point 1½ inches within and above the anterior superior iliac spine to just external to, and ½ inch above, the middle of Poupart's ligament (Fig. 108, F). Through this the aponeurosis of the external oblique is divided along the course of its fibres, as also the internal oblique and transversalis. The transversalis fascia is now carefully incised; it varies considerably in thickness, being sometimes well developed, but is occasionally so attenuated as to be scarcely recognisable. The fingers are now introduced into the wound, and the peritoneum and its contents stripped from the iliac fossa, and drawn inwards and forwards, where they are kept out of the way by a broad spatula. In the space thus opened up one can see the iliacus muscle covered by its fascia, and to its inner side the rounded outline of the psoas. The vessel lies to the inner border of this, and can usually be readily found, enveloped in a fascial sheath, with the genito-crural nerve coursing over it, and perhaps some lymphatic glands upon it. The artery is separated from the vein which lies to the inner side, and the needle passed from within outwards. If the transversalis fascia has not been properly opened, it is quite possible to strip it up together with the peritoneum, and carry the vessels forwards with it, when they may be found under cover of the spatula.

Of these two operations, the latter is probably the better. By Cooper's method the artery is tied very close to important collateral branches, whilst but a small portion of the trunk is exposed, so that if this is diseased and unsuitable for the application of a ligature, no further choice is possible. In Abernethy's, on the other hand, the vessel is tied well away from collateral branches, and if the exposed portion of the trunk is diseased, the common iliac can be reached and secured without much difficulty by extending the incision upwards. The wound also involves muscular tissue, and therefore better repair is secured with less likelihood of a subsequent hernia.

Collateral Circulation.—Anterior set : Superior epigastric of internal mammary, lumbar, and lower intercostals *with* superficial and deep epigastric in sheath of rectus.

Posterior set : Gluteal and sciatic *with* internal and external circumflex and first perforating of profunda at back of great trochanter (crucial anastomosis).

External set: Ilio-lumbar and gluteal *with* deep and superficial circumflex iliac and ascending branch of external circumflex.

Internal set : Obturator *with* internal circumflex; and terminal divisions of internal pudic *with* superficial and deep external pudic.

The **Common Femoral Artery** is but rarely ligatured, except as a preliminary measure in amputation at the hip-joint, since the number of branches arising from it is likely to interfere with its sound occlusion, and the collateral circulation is better after ligature of the external iliac. It may be reached by a vertical incision over the line of the vessel, extending both a little above and below Poupart's ligament. The superficial lymphatics and veins must be carefully avoided, the fascia lata divided, the sheath exposed and opened, and the ligature passed from the inner side.

Collateral Circulation.—Internal set : Obturator *with* internal circumflex, and internal pudic *with* external pudic.

External set : Circumflex iliac *with* ascending branch of external circumflex.

Posterior set : Gluteal and sciatic *with* internal and external circumflex, and first perforating; comes nervi ischiadici *with* perforating of the profunda and muscular of popliteal.

The **Superficial Femoral Artery** is indicated by a line drawn from midway between the anterior superior spine and the symphysis pubis to the tuberosity of the internal condyle, the limb being flexed, abducted, and everted. It may be secured at ' the site of election '—*i.e.*, at the apex of Scarpa's triangle—or in Hunter's canal.

Ligature at the Apex of Scarpa's Triangle.—A 4-inch incision is made in the line of the artery, the centre being about 4 inches (or a hand's breadth) below Poupart's ligament (Fig. 108, H). The integument and fasciæ are divided, the inner border of the sartorious exposed, and the sheath found immediately behind it, the muscle being drawn slightly outwards; the middle cutaneous nerve is perhaps brought into view. The vein is placed behind the artery at this level.

Collateral Circulation.—External circumflex *with* lower muscular of femoral, anastomotica magna, and superior articular of popliteal.

Profunda femoris by its perforating and terminal branches *with* the muscular and articular branches of femoral and popliteal.

Ligature in Hunter's Canal.—An incision 4 inches in length is made along the line of the artery in the middle of the thigh (Fig. 108, K). The sartorius is exposed by division of the fascia lata, its fibres running downwards and inwards; its outer border should be defined, and the muscle retracted inwards. The aponeurotic covering of Hunter's canal is now in view, stretching between the adductor longus and vastus internus; it is incised, and the sheath of the vessel found below it, with the nerve to the vastus internus lying to its outer side, the long saphenous nerve crossing it from without inwards, and the vein passing behind it, to become external lower down. A common mistake made by students in tying this artery on the dead subject is to burrow down along the vastus internus on the outer side of the vessels; this is to be avoided by always keeping close to the under surface of the sartorius until the glistening transverse fibres of Hunter's aponeurosis are clearly visible.

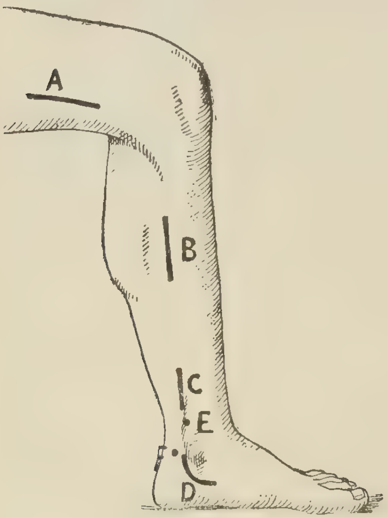

FIG. 109.—INCISIONS FOR LIGATURE OF THE UPPER PART OF THE POPLITEAL (A), AND OF THE POSTERIOR TIBIAL ARTERIES (B, C, and D).

E, Site for Introduction of knife in Tenotomy of Tibialis Posticus; F, Ditto for Tendo Achillis.

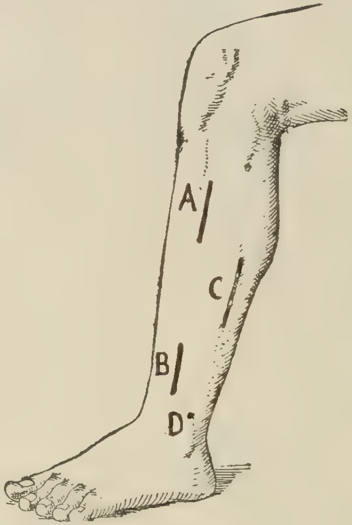

FIG. 110.—INCISIONS FOR LIGATURE OF ANTERIOR TIBIAL (A AND B) AND PERONEAL (C) ARTERIES. D, SITE FOR INTRODUCTION OF KNIFE IN TENOTOMY OF PERONEI.

Collateral Circulation is maintained through the profunda and its branches.

The **Popliteal Artery** may be tied either just after it has passed through the adductor opening, or in the depths of the popliteal space, but preferably in the former situation. Neither operation is often required.

To tie the *upper part*, the limb is fully abducted and everted so as to enable the adductor tubercle and tendon of the adductor magnus to be clearly defined. An incision, 4 inches in length, is then made from the tubercle upwards (Fig. 109, A), and the tendon exposed. The internal saphenous vein and nerve may be seen, but are drawn backwards by means of a broad retractor, together with the sartorius, gracilis, and semi-membranosus. If possible, the branch of the anastomotica magna which courses along the tendon should be spared The fascial space behind is now opened up, and the artery found surrounded by a good deal of loose connective tissue. The vein is usually seen on the outer side, and is here very thick and dense, so that in the dead subject it can be readily mistaken for the artery.

The *lower part* is tied through an incision in the middle line of the popliteal space, dividing the deep fascia and drawing out of the way the heads of the gastrocnemius muscle and the internal popliteal nerve. The vein is superficial to the artery, and is found by following the short saphenous trunk.

Collateral Circulation is maintained by the anastomoses around the knee-joint.

The **Posterior Tibial Artery** but seldom requires to be ligatured except for hæmorrhage, or on the face of amputation stumps; hence the operations described below are rarely seen away from the dead-house. The line of the vessel is indicated by one drawn from the centre of the popliteal space to a point a finger's breadth behind the internal malleolus.

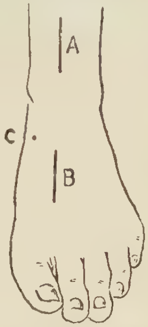

FIG. 111.—INCISIONS FOR LIGATURE OF LOWER PART OF ANTERIOR TIBIAL (A) AND DORSALIS PEDIS (B) ARTERIES. C, SITE FOR PERFORMING TENOTOMY OF TIBIALIS ANTICUS.

1. *In the Middle of the Calf.*—The leg is placed on its outer side and flexed, and an incision 4 inches long is made a finger's breadth behind the inner border of the tibia (Fig. 109, B), dividing the skin and subcutaneous tissues, the long saphenous vein and nerve being drawn aside if necessary. The tibial origin of the soleus is thus exposed, and incised directly towards the tibia, until the fibrous aponeurosis on its deeper surface is met with. This having been cut through, the muscle is drawn backwards with the retractor, and the vessels, ensheathed in a deep layer of fascia, are seen lying on the tibialis posticus, and with the posterior tibial nerve to the outer side.

2. *In the Lower Third of the Leg.*—An incision is made midway between the tendo Achillis and inner border of the tibia (Fig. 109, C). The skin and fasciæ, including the upper part of the internal annular ligament, are divided, and the vessels seen lying on the flexor longus digitorum, with the nerve behind and to the outer side.

3. *Behind the Malleolus.*—An incision is made about a finger's breadth from the malleolus, curving round its lower border (Fig. 109, D). The deep fascia (or, as it is here termed, the internal annular ligament) is divided over the vessels between the tendons of the flexor longus digitorum and flexor proprius hallucis, and the artery is then readily cleared and ligatured. The sheaths of the tendons should not be opened.

The **Anterior Tibial Artery** is found along a line stretching from a point midway between the outer tuberosity of the tibia and the head of the fibula above to the central point between the two malleoli below. It may be tied in three situations.

1. *In the Upper Third of the Leg.*—An incision is made exactly in the line of the artery (Fig. 110, A), and the deep fascia incised. The intermuscular space between the tibialis anticus and the extensor communis digitorum is opened. The vessel lies between these muscles upon the interosseous membrane, the anterior tibial nerve being to the outer side.

2. *In the Middle of the Leg* (Fig. 110, B).—The same intermuscular space is opened, being indicated here by a definite white line, due to a slight subfascial deposit of fat. The vessels lie between the tibialis anticus and the deeply-placed extensor proprius hallucis, the nerve usually lying on the artery and needing to be drawn aside.

3. *In the Lower Third of the Leg.*—An incision is made in the line of the artery, reaching upwards for 2 inches from a point just above the ankle (Fig. 111, A). The deep fascia and upper part of the annular ligament are divided, and the vessel is found between the tendons of the tibialis anticus and of the extensor proprius hallucis, the nerve lying to the outer side,

The **Dorsalis Pedis Artery** extends from the centre of the line between the two malleoli to the interval between the bases of the first two metatarsal bones. An incision is made in this direction (Fig. 111, B), the deep fascia opened, and the artery found lying between the extensor proprius hallucis, which has now crossed and is internal to the vessel, and the innermost slip of the extensor brevis digitorum. It is not always easy to find, and for practical purposes the best plan would be to divide the vessel by an incision extending to the bones, and then pick up and tie the bleeding ends.

The **Peroneal Artery** can be reached through an incision along the posterior border of the centre of the fibula, the leg being laid on its inner side (Fig. 110, C). The outer edge of the soleus is defined and drawn inwards, the lower fibres of attachment to the fibula being divided if necessary. The flexor longus hallucis is thereby exposed, and incised in such a manner as to allow the surgeon to reach the postero-internal border of the fibula; the artery is then readily found lying in an osseo-aponeurotic canal.

CHAPTER XIV.

AFFECTIONS OF THE VEINS—ANGIOMATA.

Venous Thrombosis.

By **Thrombosis** is meant intravascular coagulation in any part of the circulatory system. Normally, the blood remains in a fluid condition, owing to some inter-action between it and the vessel walls. Any factor producing a disturbance of this normal equilibrium may determine thrombosis, and any part of the vascular tract may be affected by it, whether the heart, arteries, veins, or capillaries; but it is in the veins that it occurs most frequently.

Causes.—(1) *Changes in the vessel walls*, as a result of which the integrity of the endothelium is disturbed—*e.g.*, injury (either division, rupture, puncture, compression, or contusion), inflammation or degeneration (as in varicose veins).

(2) *Changes in the constitution of the blood* whereby its coagulability is increased. In clinical work this is brought about most frequently by infective conditions, which lead to an excess of toxins in the blood. Hæmorrhage up to half of the whole amount in the body also increases its coagulability, but excess of leucocytes, as in leukæmia, has the opposite effect.

(3) *Diminished rate of the blood-stream* predisposes to thrombosis if some other condition is present to determine it. Lister showed years ago that blood can remain fluid for a long time if confined in a tube formed of a suitable length of healthy vein wall; but when either of the preceding factors is present, a retardation of the blood-stream materially assists in causing coagulation. Thus, when a vein is pressed upon by a tumour, the obstruction to the blood-flow produces a clot at the spot where the nutrition of the wall is interfered with. After fevers, such as typhoid, where the character of the blood is somewhat altered and the action of the heart weakened by changes in the muscular fibres, the defective *vis a tergo* causes a retardation of the flow in the veins, as a result of which the intra venous pressure is diminished, and coagulation is probably determined by some slight injury or pressure which is not noticed by the patient.

The **Character** of the clot varies with its rate of formation. If developed slowly, the so-called white thrombus is met with, consisting merely of layers of fibrin, similar to that formed in an aneurism. If the process is more rapid, a certain number of red corpuscles are entangled in the meshes of the clot; sudden coagulation produces the ordinary red thrombus, which at first is not adherent to the wall, but becomes so later on, especially at its base. Bacteriological examination will often reveal the presence of organisms in the thrombus.

The **Effects** of thrombosis may be considered under the following headings: local, distal, and proximal.

Locally : (*a*) The clot may be organized into connective tissue, a fibrous cord replacing the vessel in the same way as was described for arterial thrombosis (p. 287). Three weeks is about the shortest period to allow for the safe fixation of the clot within the vessel. (*b*) The lumen of the vein may be re-established by the fixation of the thrombus to one side of the vein wall, or by canalization of the clot or of the fibrous cicatrix replacing it, owing to the dilatation of the vessels contained within. (*c*) The clot may shrink or become loosened in an ampulla or a varicose vein, forming a fibrinous mass, which is subsequently infiltrated with calcareous particles, constituting a vein-stone or *Phlebolith.* (*d*) Suppuration may occur in and around the clot as a result of its bacterial contents. The result will be the formation of an abscess locally, which may be limited, or may spread widely along the course of the vein (periphlebitis), and in all probability the development of pyæmia. This may be hindered for a time by the formation of a cap of healthy red clot, which covers over and protects the infected portion.

Distally, congestion of the terminal veins results, and if a main trunk is affected, œdema of the limb follows, and possibly ulceration or gangrene. If, however, the condition affects the femoral vein of a person in the recumbent position, there may be little or no œdema as long as the limb is elevated. In favourable cases collateral circulation is soon established by the opening up and dilation of other venous channels, which after a time may become varicose, and, if situated superficially, are often very obvious. Thus, if the external iliac vein is occluded above Poupart's ligament, a greatly increased amount of blood will be carried by the internal saphena vein, and some of it will find its way *viâ* the superficial epigastric and pudic veins across the middle line to the internal saphena of the opposite side. These branches become dilated and varicose, and the inverted Λ of the two superficial epigastric veins is very characteristic. If the inferior vena cava is obstructed, the mammary and epigastric veins become dilated and tortuous, the latter standing out prominently on the anterior abdominal wall (Fig. 112).

Proximally, the process may gradually extend upwards, and finally involve larger and more important trunks than that in which it originated. Moreover, a portion of a thrombus may be detached as an *Embolus* (Fig. 113, B). If the clot is undergoing molecular disintegration, and only minute portions are set free, they are filtered off by the lungs or kidneys, and no symptoms need be caused. If, however, a large portion is detached, urgent dyspnœa and even death occur from obstruction to the pulmonary vessels and subsequent arrest of the circulation. If the clot becomes infected, and fragments conveying organisms are carried into the circulation, pyæmia is the result, preceded, however, in the portal area by pylephlebitis—*i.e.*, suppurative phlebitis of the portal trunks in the liver.

Venous thrombosis is of most interest to the surgeon when it involves the main femoral or iliac vein, and is then most frequently seen on the left side of the body, possibly spreading to the vena cava, and developing at a later date in the other limb. It is not an uncommon complication of parturition, and is then due to extension of the clotting from the pelvic veins (*phlegmasia alba dolens*). From a similar cause it may follow operations on the pelvic viscera—*e.g.*, hysterectomy. It is not a rare complication of suppurative appendicitis, and may spread from veins divided in the parietal incision, or on the right side from direct involvement of the iliac vein in the inflammatory trouble; it may develop in the course of typhoid fever; or, finally, any condition or operation which depresses the patient's vitality and keeps him bedridden with the legs quiet may lead to this trouble. Thus, one of the worst cases we have seen occurred

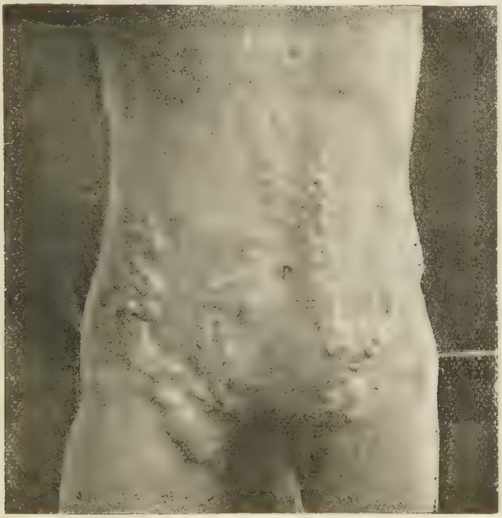

FIG. 112.—VARICOSE CONDITION OF THE VEINS OF THE ABDOMINAL WALL SECONDARY TO PERMANENT OBSTRUCTION OF THE INFERIOR VENA CAVA.

The original of this photograph is a doctor in active practice, and the thrombosis of the vena cava occurred twenty-seven years previously, after an accident. On one or two occasions severe hæmorrhage has occurred from the dilated veins.

after a severe operation for glands in the neck, which healed by first intention.

The **Clinical Signs** and **Treatment** are as for Phlebitis (p. 346).

Embolism.

An **Embolus** is the term applied to any foreign body which travels for a greater or less distance in the bloodvessels until it becomes lodged within them and causes obstruction. There are four main varieties of embolus: (*a*) **Simple Emboli**—*e.g.*, blood-clot, granulations or fibrinous vegetations from the cardiac valves after acute endocarditis, atheromatous plates, air-bubbles, fat globules, etc. (*b*) **Infective Emboli** consist of either zooglœa masses of bacteria or disintegrated portions of blood-clot carrying micro-organisms, and are the cause of the abscesses in pyæmia. (*c*) **Malignant Emboli** are formed by portions of some malignant growth, from which the various secondary deposits originate; these are met with more frequently in the sarcomata than in the carcinomata. (*d*) **Parasitic Emboli** also occur, such as the ova and scolices of the *Tænïa echinococcus* and the *Filaria sanguinis hominis*.

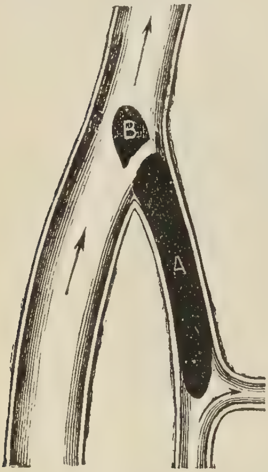

FIG. 113.—THROMBUS AND EMBOLUS. (KEEN AND WHITE.)

, Thrombus *in situ;* B, embolus detached from the same.

Emboli may be detached from the heart, veins, or arteries, although necessarily they are never arrested in a systemic vein, but only in the arteries or portal vein. They are of all sizes, and the character of the resulting symptoms depends much on this. A large embolus started in a peripheral vein lodges in one of the branches of the pulmonary artery, and may cause instant death; a smaller one is arrested in one of the smaller arteries of the lung and may do but little harm, whilst minute ones may possibly pass through the pulmonary capillaries to the left side of the heart, and subsequently become impacted in the systemic vessels.

Effects of an Embolus. The **Local** effects of the lodgment of a simple embolus consist, firstly, in the deposit of fibrin upon it, rendering the obstruction complete, if this is not already the case; organization of the thrombus usually follows, although occasionally it may disintegrate and disappear. The local effects of infective, malignant, and parasitic emboli are dealt with elsewhere.

The **Distal** effects of embolic obstruction depend entirely on the relation of the vessel blocked to the surrounding circulation.

(1) Should the embolus be lodged in an artery which gives off anastomotic branches below the point of obstruction, or if the capillary anastomosis is abundant, a **transient anæmia** is all that occurs in most cases. If the artery is small, or goes to unimportant structures, no symptoms need arise from this; but if the vessel is large, or supplies delicate and important tissues, serious results may follow even a temporary arrest of the circulation; thus, embolus of the central artery of the retina always causes permanent blindness, although the retina still lives.

(2) Should the embolus block what is called a 'terminal artery' (*i.e.*, one with no anastomosis between the embolus and the terminal capillaries), or a vessel with insufficient collateral circulation, the obstruction will lead to **death** of, at any rate, a portion of the anæmic region—*e.g.*, gangrene in a limb, or

white or yellow softening in the brain. In an organ such as the kidney or spleen, the result of embolic obstruction to one of the terminal arteries is the development of an **infarct**; *i.e.*, a wedge-shaped area of tissue with the blocked artery at its apex becomes devitalized, and in consequence looks white and feels firmer than the surrounding parts. The tissues cannot be properly stained for microscopic purposes. Sometimes the anæmic area becomes engorged with blood to such an extent as to lead to extravasation, and a firm, solid patch of a dark red colour results, known as a **hæmorrhagic infarct.** Whatever its appearance, the infarct is subsequently invaded by granulation tissue developed from the surrounding healthy parts, and this finally results in the formation of a depressed cicatrix containing, perhaps, a few hæmatoidin crystals. The conditions necessary for the production of an infarct are met with in the lungs, spleen, kidney, and brain; in the liver the anastomosis is generally too free to allow of its formation, although it has been known to occur.

Effects of the Lodgment of Emboli in Various Organs.—In the **Brain,** the middle cerebral artery is most commonly blocked, resulting in immediate hemiplegia, which may be almost entirely recovered from, but commonly leaves some impairment of function. In children the symptoms are less marked, but aneurism of the affected vessel occasionally follows. In the **Central Artery of the Retina,** sudden, total, and irremediable blindness is produced; the branches of the vessel are seen to be almost empty, the retina becomes œdematous, the macula alone retaining its normal colour, appearing as a cherry-red spot, contrasting markedly with the pallid œdematous tissues around. In the **Lung,** fatal results supervene from obstruction to the main pulmonary artery; attempts have been made to save life by opening the chest, incising the pulmonary artery, and scraping or pulling out the clot, and subsequently suturing the vessel. It is obvious that such a proceeding is not often likely to be feasible. If one of the smaller branches is blocked, a certain amount of pain and dyspnœa is produced, followed by the formation of an infarct, as indicated by blood-stained sputum, dulness, bronchial breathing, and bronchophony. In the **Liver,** an embolus of the hepatic artery causes sudden hypochondriac pain, and perhaps a temporary glycosuria. The portal vein and its branches are not unfrequently obstructed by emboli, which, being usually of an infected nature, give rise to pyæmic symptoms (pylephlebitis). In the **Spleen,** a sudden pain in the left hypochondrium is experienced, the organ becomes enlarged, and a considerable rise of temperature may follow. In the **Kidney,** sudden pain in the loin and a temporary hæmaturia constitute the main symptoms. In the **Intestine,** localized ulceration or extensive gangrene is likely to follow, according to the size of the vessel obstructed. In the **Limbs,** the emboli usually lodge at the bifurcations of main vessels, often saddling across the fork, and blocking both branches. Sudden pain is felt at the spot, shooting downwards, and either recovery or gangrene ensues (p. 113). Here, also, it has been attempted to remove or tunnel the clot by open operation, but the results have not been satisfactory; massage to break it up and drive it on may also be tried.

Phlebitis.

Phlebitis, or inflammation of the vein wall, arises from a variety of causes, and is not uncommon in surgical practice. The following forms are described:

1. **Simple Phlebitis,** in which a more or less *localized* inflammation of the wall of a vein is attended by thrombosis, which extends for a variable distance up and down the vessel. (*a*) It may arise from *injury*, either subcutaneous or open, or from the continued pressure and irritation of a tumour or aneurism; (*b*) it may be gouty or rheumatic in nature, attacking the larger veins of the lower extremity,

or vessels which have been long subject to varix. (*c*) It may follow primary thrombosis, either in the main trunk or in a varicose peripheral vein; or (*d*) it may be induced by inflammation of the tissues around the vein (*periphlebitis*), usually of bacterial origin. In the last case the bacteria gradually spread through the vein wall, and finally invade the clot.

2. **Infective Phlebitis** is a much more serious condition, inasmuch as the thrombus resulting therefrom is always invaded by micro-organisms, and the disease is often of the *spreading* type. It arises (*a*) in traumatic cases where asepsis has not been maintained, the organisms invading the clot which lies in the open mouth of the vein; or (*b*) as a result of infective periphlebitis in wounds, or in infective inflammation of bones, such as when a suppurative mastoiditis leads to disease of the lateral sinus; and (*c*) by auto-infection of the clot present in simple phlebitis, as, *e.g.*, in varicose veins.

Morbid Anatomy.—The walls of the vein are congested and thickened, and the endothelial lining is hypertrophied; the thrombus contained in the vessel varies in its characters. If aseptic, it early becomes adherent to the vein wall and organized, or is absorbed. If infected, it becomes soft and pultaceous, resembling dirty-looking pus; a localized abscess may form within the vein, and the suppuration may extend for some distance along and around the vein. In the more favourable cases the spread of the infection is limited by the terminal portions of the clot remaining firm and unaffected.

The **Symptoms** of inflammation of a **superficial** vein are sufficiently obvious. The vessel becomes swollen, hard, and painful, with localized enlargements or knobs corresponding to the valves or to the pouches in varicose veins. The skin over them is dusky and congested, and there may be some œdema of the region from which the blood flowing in the vein is gathered; this, however, rarely amounts to much, since the collateral circulation is always abundant. The temperature is usually raised, and the patient feels ill. If suppuration occurs, the signs of a localized abscess are noted, and perhaps pyæmic manifestations supervene.

When the **deeper** veins are involved, it may be impossible to detect them on palpation, although a blocked common femoral can usually be felt; but acute deeply-seated pain over the vein and well-marked fever are characteristic evidences of what has occurred. Œdema of a more or less solid character develops, although if the limb is maintained in the horizontal position throughout the attack this need not occur. Obliteration of the vessel, and any of the local, distal, or general processes detailed as characteristic of thrombosis (p. 342) may result.

The onset of an **infective periphlebitis** is marked by fever and perhaps rigors, whilst the local signs are due to rapid extension of a suppurative inflammation along the vein and its branches, so that a large tract of tissue is very quickly invaded, and diffuse suppuration follows. The onset of pyæmia is indicated by a repetition of rigors, and the development of secondary abscesses.

Treatment.—In the **simple** variety the limb is kept absolutely at rest to limit the inflammation and prevent the detachment of emboli, and also elevated to assist venous return. Locally, belladonna fomentations may be applied, or the parts may be painted with glycerine and extract of belladonna, swathed in a thick layer of cotton-wool, and lightly bandaged. The patient should be kept on an unstimulating though nutritious diet, and the general health attended to. When every sign of inflammation has subsided, and sufficient time has been allowed for the absorption or organization of the clot (three weeks as an absolute minimum—six weeks for choice), massage may be commenced, to assist in the removal of œdema and local thickening, and an elastic bandage is usually serviceable in restoring the circulation. Operation is sometimes undertaken in cases of phlebitis associated with varix, but not when the deeper veins are involved. If abscesses form, they must be opened antiseptically.

Infective phlebitis is treated in a similar fashion until suppuration occurs, and then the pus must be evacuated, and it is sometimes remarkable to note how quickly the process quiets down when once drainage is effected. A **spreading periphlebitis** will often involve an extensive area, but the process must be followed up ruthlessly by the knife and the parts laid open. The wounds thus made should be lightly packed and allowed to granulate; at the same time the limb is raised and kept absolutely quiet. Should pyæmic phenomena develop, it may be necessary to place a ligature between the disintegrating clot and the heart, and to scrape or wash away the infective material; thus, in thrombosis of the lateral sinus, following suppuration in the middle ear, the internal jugular vein should be ligatured, the lateral sinus opened, and the clot removed. Of course, such treatment is only feasible in cases where a single trunk is affected. When the process involves the veins of a limb, and cannot be stopped by either of these plans of treatment, the question of amputation may have to be raised.

Varicose Veins, or Varix.

A vein is said to be in a condition of varix when it has become permanently lengthened, dilated, and more or less tortuous. The superficial veins of the leg, especially the internal and external saphena, are those most commonly affected; the spermatic veins are often in a similar condition, constituting what is known as a varicocele, whilst piles are primarily due to varicosity of the hæmorrhoidal plexus. We shall here only deal with the first of these three manifestations.

Causes.—Varix is due, in the first place, to some inherited weakness of the venous wall, or irregularity in the arrangement of the valves, though possibly this produces no effect until some exciting cause comes into action and throws a strain on the circulation. The facts that varix sometimes appears quite early in life and without adequate cause, and often involves the same vein in different members of a family, confirm this statement.

Any condition which leads to frequently repeated or more or less permanent distension of a vein may result in varix—*e.g.*, prolonged standing, as in those serving behind counters; the pressure of tight garters, especially if worn below the knee; prolonged or forcible exertion of the limb; the pressure of a pregnant or displaced uterus, or of a pelvic tumour. Severe exertion—such as occurs in football-playing, hard training, weight-lifting, etc.—throws a heavy strain on the vein walls, and sometimes leads to the giving way of the valves, usually from above downwards in the legs. This valvular incompetence results in increasing pressure on the venous walls, which gradually pass into a condition of varix.

Obstruction to and occlusion of the deeper veins is another well-recognised cause of varix, and we have already drawn attention to the effects produced by blocking of the common femoral vein and inferior vena cava. A less known instance is the varix of the internal saphena or some of its branches below the knee which follows thrombosis of the venæ comites of the posterior tibial, due to strains of the leg and similar injuries. If the thrombus is absorbed, the dilatation disappears; but if the block is permanent, the superficial veins become varicose, usually extending to just below the knee. Any abnormal communication between an artery and a vein also causes varix, from the inability of the latter to withstand arterial blood-pressure (*vide* Aneurismal Varix, p. 302). The tendency to varix increases with age till the middle period of life is reached, and is favoured by the relaxation of the system resulting from sedentary habits. When once a vein has become varicose and its walls thin and expanded, the valves become incompetent, and the weight of the superincumbent blood still further increases the mischief.

Morbid Anatomy.—To the naked eye a varicose vein in an early stage appears thickened, distended, and tortuous; the walls are so thick that the vein when cut across does not collapse, but presents a gaping mouth, like an artery; the valves atrophy, and are functionally useless. After a time the walls become further stretched and irregularly expanded, forming here and there cyst-like dilatations, which are very obvious under the attenuated skin, to which they are often adherent. Microscopically, the change consists in a transformation of the normal structures of the vein wall into fibro-cicatricial tissue. The tunica media is mainly affected, most of the muscular fibres disappearing, whilst the tunica intima is but little changed, and the adventitia thickened. In the pouches the middle coat is atrophied, and, indeed, is often completely absent.

Clinical History.—The enlarged veins are seen ramifying under the skin with a more or less tortuous and serpentine course (Fig. 114), and they often feel thickened. One or more veins may be affected, and the tortuosity may be at parts so marked as to constitute large clusters of dilated vessels, which look bluish under the thin and stretched integument. In other cases a single vein is enlarged, and stands out prominently under the skin; or perhaps one or more cyst-like pouches develop in connection with these (Fig. 115). The upper end of the internal saphena is sometimes dilated so as to form a large pouch, in which a marked thrill is felt when the patient coughs, thereby simulating a femoral hernia. In other cases, although this portion of the vein is not dilated, yet its valves are incompetent, and the thrill produced by coughing can be felt even below the knee if that portion of the vein is dilated.

The **Effects** of varicose veins are very varied. The limb often feels heavy and tired; forcible exertion may cause a sensation of tension and after standing or exercise there is usually some œdema of the ankle. The capillaries in the papillæ often become dilated, appearing as minute reddish puncta, which subsequently run together and form brownish patches of pigmentation. Eczema is induced by the irritation of rough and coarse trousers or dirt, often terminating in actual ulceration. Any lesion, such as a scratch or abrasion, instead of healing readily under a scab, tends to spread and form an ulcer. Injury to the vein may lead to thrombosis and subsequent cure, but coagulation sometimes occurs spontaneously in cysts or acute kinks, especially in gouty subjects. The clot may subsequently shrink and

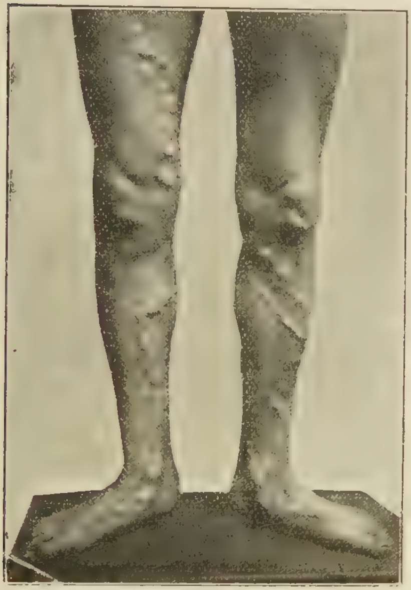

FIG. 114.—VARIX OF INTERNAL SAPHENA VEINS.

The left foot is a good illustration of pes planus (flat-foot).

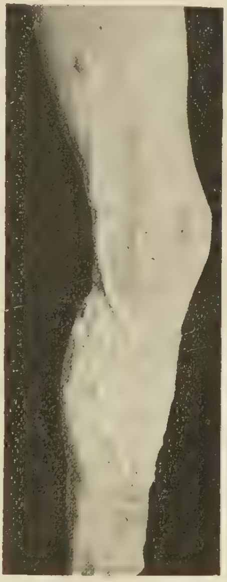

FIG. 115.—VARIX OF LEFT INTERNAL SAPHENA, SHOWING AN AMPULLA ABOVE.

form a small fibrinous or calcareous mass, known as a 'phlebolith,' but sometimes the thrombosis spreads into deeper or larger veins, and then fragments of clot may be detached as emboli. Occasionally the dilated pouch of a varicose vein gives way, and an alarming rush of blood results; the same may follow the extension of ulceration through the vein wall. The blood under these circumstances is derived, not only from the lower, but also from the upper end; and if the valves have become incompetent, a column of blood extending from the right auricle is thus tapped near its lower end, and, unless prompt precautions are taken, the patient's life may be lost.

The **Treatment** of varicose veins may be described as palliative and radical.

Palliative Treatment consists in removing any source of obstruction in the shape of tight garters, in limiting the amount of standing, in moderate massage, together with the application of either an elastic stocking or an indiarubber bandage. The bowels should be regulated, and the general health attended to. Eczema may be treated by the application of soothing and drying ointments, *e.g.*, ung. zinci benzoatis; or if the skin is chronically infiltrated and thickened, by the use of weak tarry applications, *e,g.*, ol. Rusci (1 part to 4 of vaseline), or of ichthyol (5 or 10 per cent. in vaseline). Varicose ulcers are suitably treated (p. 103), but repair is often delayed till the veins have been dealt with by operation.

Radical Treatment consists in the excision of the distended veins. Before operating it is important to investigate the history and ascertain if the condition is due to thrombosis of the deep trunks, as interference might then do more harm than good. Operation is specially indicated when thin, dilated pouches exist; when elastic stockings cannot be comfortably worn, as in the tropics; when ulcers are present which refuse to heal; when the condition is very extensive and painful, and especially if large bunches of dilated veins are seen; or when there is a distinct impulse or thrill on coughing, due to valvular incompetence.

Various methods of operating have been adopted: (*a*) Small portions may be removed at several different situations. The skin is pinched up over the vein, and incised by transfixion; the vessel is usually bared by this means, but may need a little clearing. An aneurism needle is passed beneath it, and the vein isolated sufficiently to allow of its being grasped by two pairs of forceps, and divided between. Each end is now freed, and drawn out of the wound as far as possible; it is then ligatured and removed. Probably 2½ inches of vein may be taken away through a 1-inch incision. The wound is sutured without drainage and dressed. (*b*) Long incisions are made, perhaps 6 inches or more, through which larger clusters of veins may be dealt with. The wound should not lie over the most dilated parts of the vessel, as there the skin is often thin and unhealthy, but should be curved so as to include as much sound skin as possible, whilst crossing the vessels once or twice. All collateral branches, especially the deep ones, must be secured, and this, in fact, constitutes the great advantage of the operation, viz., that so many anastomosing channels are obliterated. In very bad cases most extensive operations are sometimes required, the incisions involving nearly the whole length of the limb. (*c*) A simpler procedure has been advocated by Trendelenburg, viz., the removal of a portion of the internal saphena close to the saphenous opening, so as to break the weight of the superjacent column of blood. In many cases, but especially where there is an impulse on coughing, and the vein fills from above, this is essential, though it is also desirable that the enlarged veins lower down should be excised.

After an operation for varix the patient should remain in the recumbent posture for three weeks, to allow clots to become firm and to permit the circulation to accommodate itself to the new arrangements. On first rising from bed, it is well to support the limb for a time by a ‘ Crêpe Velpeau ’ bandage.

Inflamed Varicose Veins are not unfrequent, and may result in a natural cure of the condition. The symptoms are those of a superficial phlebitis, and the treatment indicated for that condition should be followed. In cases where there is much pain it may be justifiable to excise the thrombosed vessels, taking the precaution first to secure by ligature the vein above the clot, so as to prevent any risk of embolic detachment. Operation of a similar type is also required when thrombosis is gradually spreading upwards, and threatening to affect the deep trunks—*e.g.*, in the neighbourhood of the saphenous opening; or when portions of clot are being detached as emboli, giving rise to pulmonary symptoms.

Hæmorrhage from a Ruptured Vein needs prompt and decisive treatment. The bleeding spot should be commanded by digital compression, and the patient laid on the back with the limb elevated, until either a pad of antiseptic dressing can be applied to the wound. or a handkerchief or bandage secured over it.

Venesection.

Venesection or phlebotomy is a means of treatment which has largely fallen into disuse of late years, but is still occasionally employed with benefit. When a patient is becoming cyanosed, and asphyxia is threatening either (*a*) as a result of pulmonary engorgement from mitral incompetency, owing to the heart being unable to drive the blood into the systemic circulation; or (*b*) as a consequence of some accident involving the chest wall and lungs, whereby the blood-aërating surface is so diminished that it cannot deal with the blood reaching it through the right side of the heart, which hence becomes enormously distended, and threatens to stop in a condition of diastole: or (*c*) where inflammation of the brain is pending, and the pulse is hard and full; or (*d*) in a few inflammatory states in strong, full-blooded individuals where the pulse-tension is high—in any of these conditions venesection may be used with advantage.

The median basilic vein at the bend of the elbow is that usually opened, since it is larger than the median cephalic, though placed more directly over the brachial artery, from which it is only separated by the bicipital fascia.

Requisites.—A strip of bandage about 4 feet long; a scalpel or lancet; a graduated bleeding-bowl; and finally something, such as a stick or bandage, to be grasped by the hand, so as to cause contraction of the muscles, thus pressing the blood from the deep into the superficial veins along the communicating branch which enters the median just below its bifurcation.

Operation.—The patient should be seated in a chair or in bed; standing would produce syncope too rapidly, whilst the recumbent posture would allow too great an abstraction of blood before Nature's danger-signal (*i.e.*, syncope) is evident. The skin in front of the elbow having been purified, as also the hands of the surgeon and the lancet, the bandage is tied round the arm with sufficient tightness to arrest the venous circulation whilst the arterial supply is unimpeded. Grasping the stick firmly causes the veins to become prominent. The median basilic is now steadied by the left thumb, and an incision made into it (Fig. 116, A). Blood will flow from it in a full stream, and is collected in the bowl. When sufficient has been withdrawn, the stick is removed from the patient's hand, a sterilized swab is pressed over the bleeding spot, the bandage above is relaxed, and a pad of antiseptic dressing placed over the wound and firmly bandaged in position; the arm is kept at rest for a few days to allow the small incision to heal. Occasionally neuralgic pain is caused by the implication of some of the fibres of the internal cutaneous nerve in the cicatrix; whilst, if the lancet is plunged too deeply, an arteriovenous wound may be produced.

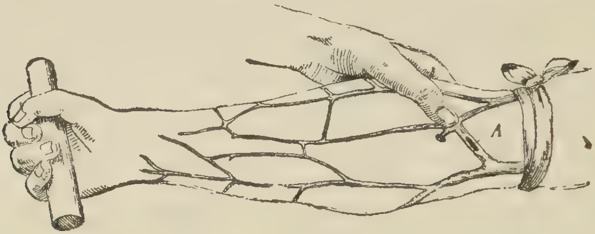

FIG. 116.—VENESECTION.

Angiomata.

Tumours of bloodvessels present varying appearances according to the situation and the character of the vessels of which they are composed. They are frequently of congenital origin or developed soon after birth. They involve most commonly the skin or mucous membrane together with the underlying tissues, and are then known as **nævi**; but they are occasionally acquired and develop in deeper organs, such as the liver. According to their structure they are divided into three main groups, the simple or capillary nævus, the cavernous nævus, and the plexiform angioma.

1. The simple or **Capillary Nævus** (mother's mark) is exceedingly common, and consists of a mass of dilated capillaries held together by a small amount of connective tissue. It is usually located in the skin, but may also involve the subcutaneous tissues; the tubular form of the constituent vessels always remains. It occurs in the form of a slightly raised flattened mass, bright red or purple in colour, according to the relative amount of arterial or venous blood present, and with occasionally a somewhat irregular or nodulated surface, in which larger vessels may be seen ramifying. Several such growths may be present in the same individual, and they are usually quite small, rarely exceeding an inch or two in diameter; they are present at birth or appear soon after. The head and face are the parts most commonly affected. Angiomata of the mucous membranes are often a source of considerable danger and trouble from hæmorrhage, especially in the bladder and nose.

A more superficial variety known as the **port-wine stain** often extends widely over the face and neck, and is somewhat dusky in colour; this condition consists merely of a network of fine vessels, and does not project above the surface.

Occasionally a nævoid development may be observed having a linear distribution down the long axis of a limb, or running transversely half round the trunk, and limited almost exactly by the middle line; this condition is known as *nævus unius lateris*. It may consist purely of a vascular manifestation, or the skin may be hypertrophied and covered with small soft papillary excrescences.

The term **Spider Nævus** (*N. araneus*) is applied to a small angioma, which develops usually in young people, and generally on the face, from which radiate a considerable series of fine red lines. When irritated they bleed easily, but are readily cured by the application of carbonic acid snow or a pointed cautery.

It is not uncommon in middle-aged people to find a number of small red spots on the trunk, which sometimes persist for a while and then disappear. These **telangiectases** (or *De Morgan spots*) consist of dilated capillaries, and are possibly degenerative in origin. At one time they were looked on as associated with cancer, and they certainly often occur in women with mammary cancer; but further experience has proved that no such sinister significance is to be attached to them.

Left to themselves, simple nævi may remain unchanged or disappear; more often they increase in size more or less rapidly, and may invade surrounding tissues, requiring active treatment in order to check their progress. Sometimes they persist unaltered till middle-life, and then may increase rapidly, giving rise to a considerable vascular tumour, purple in colour, and occasionally becoming prominent and pendulous. Such a tumour is soft and easily compressible, being in reality a cavernous angioma; it may ulcerate, and profuse hæmorrhage may result.

Treatment is usually simple in the extreme. Small superficial nævi can be completely cured by some form of cauterization, the best results being obtained by the use of carbonic acid snow. Appliances for the supply and employment of this agent are obtainable at instrument makers. In exposed situations electrolysis (p. 53) may be the best plan to adopt, but excision will often give a good result.

2. A **Cavernous Nævus** (Fig. 117) most commonly involves the subcutaneous or submucous tissues, but is sometimes associated with a superficial nævus. It consists of dilated spaces where the tubular form of the constituent vessels is lost, the arteries often opening directly into thin-walled cavities lined with endothelium without the intervention of capillaries. The tumour thus produced is a more or less prominent swelling, soft to the touch, and easily compressible, but re-filling when the pressure is removed. There is usually no pulsation or bruit, although both may be present; and the mass may be definitely circumscribed, or more or less diffuse. If subcutaneous, the skin over it is somewhat bluish in colour; when the skin is involved, the mass presents a dusky red appearance. Occasionally these growths undergo spontaneous cure from inflammation and thrombosis, and cysts are sometimes found in the centre of a nævoid mass, indicating that a partial attempt at this process has occurred. A similar condition arises in the viscera, especially the liver, and it is not difficult in certain suitable cases to demonstrate that it has been formed by a dilation of the capillaries between the lobules, the liver substance meanwhile disappearing by a process of simple atrophy.

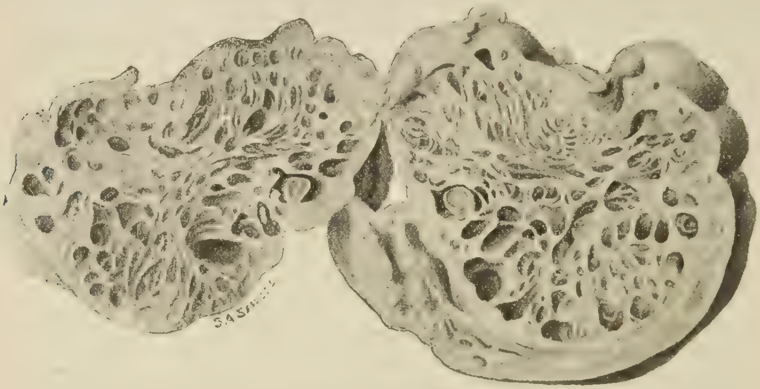

FIG. 117.—SECTION OF CAVERNOUS ANGIOMA. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

In one or two of the cavernous spaces thrombi more or less adherent can be seen.

The **Treatment** is by no means as simple as in the former variety. The following plans may be mentioned:

(1) Excision of the growth should always be adopted where practicable. The bleeding is never great, even if the nævoid tissue is encroached upon by the knife, and only a few vessels will need to be tied. Circular growths should be removed by crescentric incisions, and a little undercutting will usually enable the edges to be approximated easily. In exposed situations Halstead's subcuticular suture should be utilized.

(2) Where excision is impossible, **electrolysis** should be employed. It consists in the passage of an electric current through the mass, producing chemical and physical changes in the contained blood. For details, see p. 53.

3. **Plexiform Angioma.**—This term is now usually applied to an angioma in which the arterial element predominates, although veins and capillaries are also present. The growth is usually seen in young people, and affects most frequently the scalp, especially the temporal or occipital regions. A tumour is produced which is soft and compressible, pulsating forcibly, and with a marked bruit (**cirsoid aneurism**: p. 724). It usually consists of large obvious dilated pouches, the skin over which is thinned, and may give rise to serious hæmorrhage, or grave infective troubles. Sometimes the growth consists of smaller arteries, and partakes more of the character of an arterial nævus, but the tubular condition of the vessels is often lost. This variety (**aneurism by anastomosis**) is sometimes found in the interior of bones (p. 596), in some forms of pulsating exophthalmos, and in the scalp.

A **Nævo-Lipoma** is the name given to a somewhat rare tumour, in which a fatty element is blended with nævoid tissue. It is usually of congenital origin, or at any rate appears early in life. It gives rise to a swelling, lobulated and doughy, like a fatty tumour, although it is usually a little denser in texture than the ordinary lipoma. It may be possible to reduce its size by compression, but no thrill or pulsation can be detected; a few dilated veins or capillaries are often seen on the surface. The only treatment is excision

CHAPTER XV.

DISEASES OF THE LYMPHATICS.

Rupture or Division of the Thoracic Duct may occur as a result of a penetrating or bullet wound of the neck, or during operations in the supra-clavicular fossa. The main trunk has also been torn in a fracture of the spine, and the lymph has escaped into the pleural cavity. Wounds near the outflow into the junction of the jugular and subclavian veins usually involve one or more of the several branches into which the main trunk divides before opening into the venous system; lymph or chyle escapes, but if the divided vessel is tied, no further trouble arises as a rule. Failing ligature, the wound should be packed with gauze, and the flow generally ceases after a while. Should this not occur, an attempt must be made to anastomose the divided end of the duct with one of the deep veins, for a persistent and excessive loss of lymph means the exhaustion of the patient.

In a few cases the opening of the thoracic duct has been *obstructed* or compressed, leading to such backward tension that the receptaculum chyli has ruptured and the peritoneal and pleural cavities have been filled with a serous or chylous exudation. Virchow described one case where the opening was congenitally absent (in a calf), and the lymphatics throughout the body were enormously distended, especially those of the small intestine.

Acute Lymphangitis, or Inflammation of the Lymphatic Vessels, ensues almost invariably from the absorption and passage along the lymphatics leading from an infected wound of bacteria (usually streptococci) and toxins, which give rise to inflammation of the lymphatic vessels involved and of the tissues around them, and this may even run on to suppuration. The walls of the lymphatics become hyperæmic and infiltrated, and the tissues around are inflamed. The lymph is said to coagulate in the vessels, forming a pinkish clot. The process is usually limited by the nearest lymphatic glands, which arrest and filter off the toxic products, with or without the occurrence of suppuration; but, in spite of this, a general infection of the system occasionally results.

Clinical Signs.—The causative wound may be obviously infected, or is possibly very slight and covered by a dry scab. The characteristic appearance is that of fine red lines or streaks following the course of the lymphatics, perhaps up to the nearest glands; the parts thus inflamed are tender and œdematous. If the mischief is limited to the main trunks (*tubular lymphangitis*), they may be felt hard and cord-like, and the red lines remain isolated from each other; but if all the smaller lymphatic channels of a part are affected (*retiform lymphangitis*), the redness merges into a generalized blush, and the condition is identical with cellulitis. Localized foci of suppuration in the course of the lymphatics often follow, the redness increasing and the parts becoming dusky and brawny, until finally the centres soften and fluctuate. These phenomena are associated with fever and malaise, the temperature rising to 102° or 103°, possibly attended by rigors, vomiting, and diarrhœa.

Under suitable treatment resolution rapidly follows, but suppuration may occur either in the glands or in some loose mass of cellular tissue traversed by the lymphatic trunks, or as a chain of abscesses in the course of the vessels. Occasionally the lymphatic vessels become permanently occluded, and a form of solid or lymphatic œdema results. Recurrent attacks of this type are not uncommon in connection with chronic eczema or ulcers of the leg, and may lead to elephantiasis. In the worst cases the patient dies from general septicæmia, or from exhaustion following diffuse suppuration.

Treatment is at first directed to the causative focus, which must be opened up and purified, so as to cut off the supply of bacteria and toxins to the lymphatics. The limb itself is kept at rest in a slightly elevated position, and fomented, or soaked in a hot bath; Bier's treatment of induced hyperæmia is often useful. Abscesses are opened as soon as they develop. Any subsequent œdema is remedied by massage and firm bandaging, provided no venous complications are present.

Constitutional treatment consists in the administration of a purge, followed by a light and nutritious diet, quinine and tonics, care being taken that constipation is not thereby produced.

Chronic Lymphangitis either results as a sequela of an acute attack, or is met with as a separate condition. It is most frequently seen in connection with venereal disease, the dorsal lymphatics of the penis becoming enlarged, hard, and cord-like, especially in cases of primary syphilis. This is usually accompanied by a solid œdematous condition of the prepuce and enlargement of the inguinal glands. Under appropriate antisyphilitic treatment, the swelling quickly subsides.

A *tuberculous* type of chronic lymphangitis also exists in which a primary focus, say, on a finger, is associated with secondary deposits along the lymphatics up the arm. Each nodule is at first of firm consistency, but gradually softens and breaks down. Naturally, such a case is liable to be followed by general dissemination. The *treatment* consists in the excision, if possible, of each focus.

The cheeks and nose are occasionally the seat of a chronic relapsing lymphangitis, due to the absorption of septic material from sores within the nostril. It is characterized by patches of hyperæmia and some amount of tissue infiltration, and for its cure the causative lesions must be treated. The thick lips of a tuberculous child are of a similar nature, and due to the constant irritation of cracks along the lip margin.

Lymphatics, like bloodvessels, are liable to distension and dilatation, which may be either congenital or acquired, and are known as **Lymphangioma** or **Lymphangiectasis.** It is impossible to draw an absolute line of distinction between the two conditions, but the latter term is applied mainly to cases where normal lymphatics are dilated and their continuity with the normal lymphatic circulation persists, whilst a lymphangioma is the result of a new formation. Not unfrequently the two conditions develop side by side.

Lymphangiomata* are growths composed of newly-formed lymphatics, together with a variable amount of connective tissue, which is sometimes of a fatty nature. They may be congenital or acquired, but even in the latter case there is probably an underlying congenital element, which was only awaiting some irritation or localized injury to determine its development. Two varieties may be described, the capillary and cavernous.

(*a*) The **Capillary Lymphangioma** is usually congenital in origin, but often increases considerably as the child grows, and may attain large proportions. When developing in the skin, it may be termed a **lymphatic nævus,** and in origin and development it well merits the title. The patch is usually of a dull yellowish-brown colour, but this varies with the amount of blood present; it may be smooth-topped like a wheal, or wart-like in appearance, but on examination with a lens each projecting point contains a vesicle. This type of growth is sometimes very extensive, and may be associated with tumours of the underlying connective tissues. Thus, a large fatty mass was removed from the anterior thoracic wall of a child, the greater portion of the projecting surface of which was covered with a capillary lymphangioma. The only *treatment* for this condition is excision or cauterization.

In the subcutaneous tissues the capillary variety is often associated with large cysts of the cavernous type. It constitutes a soft swelling which when cut into has a spongy texture and exudes a large amount of lymph, with some blood. This form is rarely well defined, and may burrow widely, invading and infiltrating the tissues, and, indeed, in some cases may almost be looked on as of a malignant nature. Free excision is the only cure.

(*b*) **Cavernous Lymphangioma.**—The lymphatics here lose their tubular condition and give rise to cyst-like swellings which vary much in size.

In the skin they are rarely larger than a split pea, and may co-exist with the capillary variety. Any part of the body may be affected, and the lesion manifests itself as a series of small vesicles, which persist and are unaccompanied by any inflammatory redness, thus serving to distinguish it from herpes. They contain lymph, and, if opened, a considerable flow of this fluid (lymphorrhœa) may result, lasting for some time. They have been observed most frequently on the inner side of the thigh and on the prepuce. **Treatment** consists in excision, or in laying them open and cauterizing the base.

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* See Carless, 'Some Cases of Lymphangioma,' *Brit. Journ. of Children's Diseases*, February, 1904, p. 56.

In the deeper structures large multilocular cystic swellings may be produced; these are most frequently seen in the neck, and the condition is often termed a **Cystic Hygroma** (Fig. 118). The description given in Chapter XXXII. would apply equally well to a tumour of this nature in any other part of the body. Removal by dissection is often very difficult, especially in old-standing neglected cases; the limitations of the mass are sometimes very indefinite, and it may be necessary to leave the wound open and pack it, so as to ensure healing by granulation.

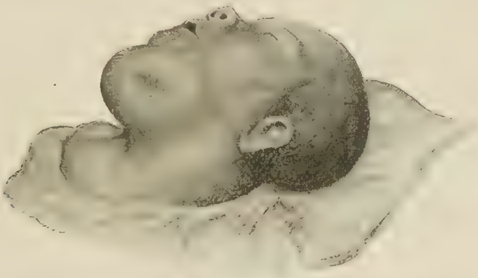

FIG. 118.—CYSTIC HYDROMA OF NECK. (FROM A PHOTOGRAPH.)

The patient was a child of a few weeks. The cyst was opened and the mass partially removed. Recurrence ensued, and a further operation of a very extensive character was required. As the lymphangiomatous tissue had invaded the sterno-mastoid and the parotid gland, it was impracticable to remove it totally. The child finally succumbed to infective lymphangitis and exhaustion.

Lymphangiectases are more frequently acquired than congenital, but the latter condition occurs, and is then probably due to some abnormal development of the lymphatics or to ante-natal inflammatory mischief.

Macroglossia and **macrocheilia** are congenital enlargements of the tongue and lip, due to lymphatic obstruction and to an associated overgrowth of the connective tissues of the parts.

The condition known as **Chylous Hydrocele**, in which there is an effusion of milky fluid (presumably chyle) into the tunica vaginalis, is probably due to some such obstructive cause. In a case under our care the lymphatics of the spermatic cord were dilated by a similar fluid in a beaded manner.

Elephantiasis is a hypertrophic condition of the subcutaneous tissues and skin resulting from chronic lymphatic obstruction. Two chief varieties are described: (i.) *E. arabum*, due to a development in the lymphatics of living parasites, viz., the *Filaria sanguinis hominis*; (ii.) the *non-filarial* type, which may arise from many causes, such as the deposit of tuberculous or cancerous material in lymphatic glands; the obliteration of lymphatic channels in operations for removing such glands; recurrent attacks of lymphangitis in cases of chronic eczema or ulcer, leading to a gradually increasing obliteration of lymphatics. The condition generally affects the legs, but the scrotum is not uncommonly involved, and occasionally the mammæ, arms, or face. The accompanying illustrations (Figs. 119 and 120) indicate that the non-filarial type may be just as severe as the other (Fig. 121), although this is unusual.

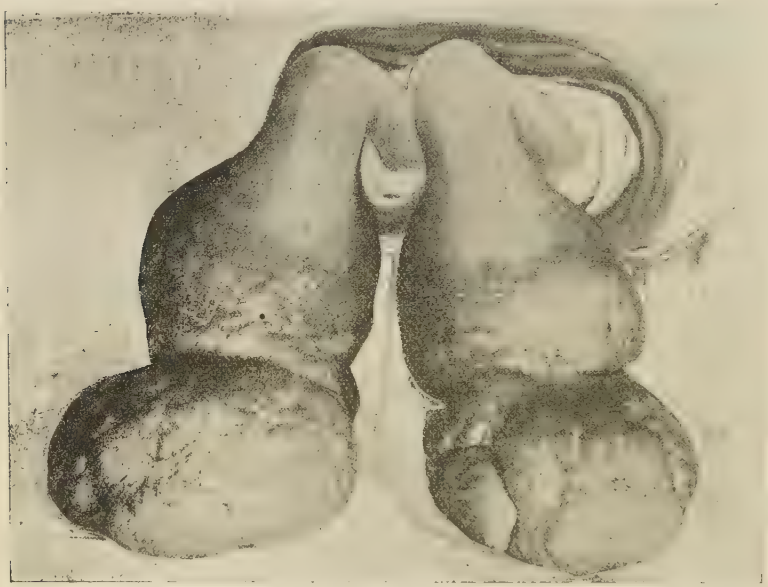

FIG. 119.—NON-FILARIAL ELEPHANTIASIS OF BOTH LEGS.

From a woman who had never been out of England. The cause was not apparent, but had been in action many years.

Three chief phenomena manifest themselves as the outcome of such obstruction—viz., (*a*) *Solid or lymphatic œdema*, a condition in which the subcutaneous tissues become firm, infiltrated, and brawny, but the fluid cannot be expressed from them, as in an ordinary œdema, and hence the part does not pit on pressure. (*b*) *Hyperplasia* follows, affecting not only the subcutaneous tissues, which are greatly thickened, but also the skin, which becomes coarse and wart-like in appearance. (*c*) The warty stage is usually preceded by a development of vesicles (dilated lymphatics) in the papillæ, and from these when ruptured a considerable flow of lymph (*lymphorrhœa*) may follow. If infection supervenes, chronic ulceration and recurrent lymphangitis may ensue.

Elephantiasis Arabum (*syn.:* **Barbadoes Leg**) requires but little notice here, as it is seldom seen in this country, being mainly limited to the tropics, especially the West Indies and South America. The legs, scrotum, and vulva are the parts most frequently attacked, but the face or breast may also be affected. It manifests itself as a hyperplasia of variable size of the subcutaneous tissues, whilst the skin becomes thickened and wart-like, and from it a copious discharge of lymph may escape. The parts sometimes attain enormous dimensions, the scrotum even reaching to the ground when the patient is sitting (Fig. 121). The disease persists for many years, and is not directly fatal.

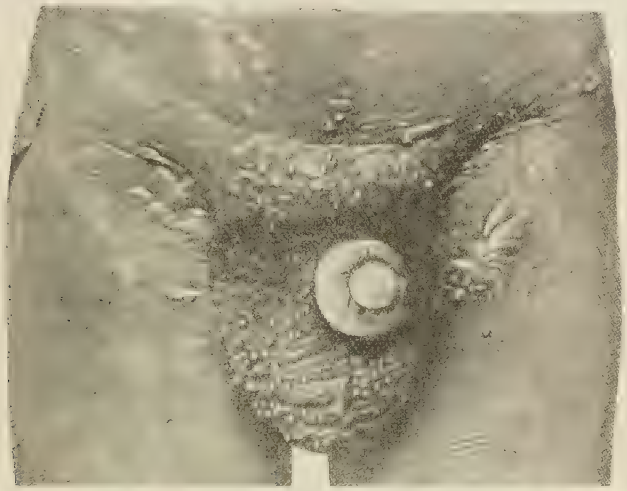

FIG. 120.—NON-FILARIAL ELEPHANTIASIS OF SCROTUM, PENIS, AND THIGHS. (FROM A PHOTOGRAPH.)

The patient was a young man, and the cause of the trouble suppuration of the inguinal glands after scarlatina; the cicatrices of the incisions required in order to deal with the glands are plainly to be seen. The scrotum was much enlarged and very solid; the skin over it was covered with papillomatous growths, due to lymphatic dilatation. The skin of the penis was much thickened, and the subcutaneous tissues infiltrated. Over the thighs were scattered numbers of vesicles, which, when pricked, exuded lymph, and some of these were becoming transformed into solid fibrous growths. The legs and feet were also in a condition of solid œdema.

The condition is due to the obstruction caused by the development of the *Filaria sanguinis hominis* in the lymphatics. These are spread by the agency of mosquitoes, in whose bodies the intermediate stage is passed. The dead mosquito, with its parasitic contents, falls upon the water, and in this medium the ova find an entrance into the human stomach, where the young worm is set free, bores through the gastric mucous membrane, and finally becomes lodged in the lymphatics, especially those of the extremities. Not more than two or three pairs of mature filariæ are generally present in the same individual. The body of the female worm (which attains a length of 3 inches) is mainly occupied by the reproductive organs, and a countless number of embryonic filariæ are produced. Some remain coiled up in the lymphatic spaces, and give rise to the phenomena of lymphatic obstruction. Others become uncoiled, and are then about $\frac{1}{80}$ inch in length; they find their way into the blood-stream, sometimes at night (*F. nocturna*), sometimes in the day (*F. diurna*), and can be readily seen under the microscope (p. 65). They are taken into the body of a mosquito with the blood which it abstracts, and thus a fresh generation is developed.

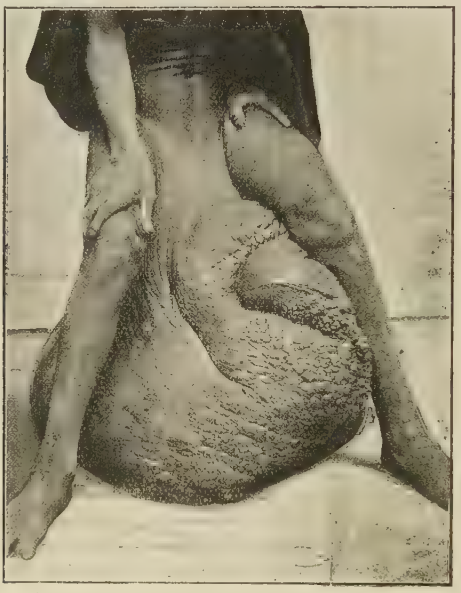

FIG. 121.—FILARIAL ELEPHANTIASIS OF SCROTUM AND PENIS IN A JAPANESE.

The **Treatment** is extremely unsatisfactory. In the *filarial* variety, if one can localize the situation of the parent filariæ, as has been possible in a few cases, they should be excised; but even then the lymphatic obstruction may persist. This may be dealt with in either variety by elevation of the limb and elastic pressure; but when the condition is due to lymphatic obstruction in the groin, it may be possible to find the dilated lymph trunks and implant them into a tributary of the internal saphena vein (*lymphangeioplasty*), so as to relieve the limb of its engorgement with lymph. It has also been suggested to construct artificial lymphatics by introducing a carefully sterilized silk thread through the subcutaneous tissues of the thickened area, leaving it buried therein, and carrying it up into normal tissues (Sampson Handley). This has acted fairly well in draining away the fluid from the brawny arms, sometimes seen in the last stages of a cancerous breast (*q.v.*), but it is of little avail in the lower extremity owing to the counter-influence of gravity. Finally, when a limb is involved, amputation may be desirable. When the scrotum is affected, the morbid tissue can be freely dissected away, sufficient skin being left to cover in the wound if possible; the penis and testes must first be isolated, and then the scrotum amputated, a tourniquet being used to restrain the bleeding.

Affections of Lymphatic Glands.

Acute Lymphadenitis, or Inflammation of Lymphatic Glands.—The **Cause** of this condition is almost always the absorption of some irritative material (toxic or infective) from the periphery. There is always an increased flow of lymph from an inflamed part, resulting in an enlargement of the glands to which the lymph is carried, which quickly subsides when the inflammatory process is at an end. In infective conditions the enlargement is more obvious and painful, and suppuration frequently results; in fact, the lymphatic glands must be looked on as the filters by means of which many sources of disease are eliminated. It is curious that certain peripheral infective conditions are not at all liable to produce lymphadenitis—*e.g.*, spreading gangrene and many forms of cellulitis; possibly the acuteness of the process causes lymphatic thrombosis, and thus hinders absorption. A certain amount of peri-adenitis is always present, even in the early stages; it may be of little importance, or be so severe and extensive as to constitute a diffuse suppurative cellulitis.

Clinical History.—The glandular trouble may be associated with a typical lymphangitis, or be independent of it, and the causative lesion may have almost disappeared before the glands become affected. The glands become enlarged and tender, and if superficial, the skin over them is red and œdematous, and the surrounding tissues are infiltrated and brawny. When pus forms, softening occurs in the centre of the mass, and fluctuation may become evident; where there is much loose areolar tissue around the glands, as in the axilla, the pus may burrow widely. Fever, malaise, and all the general phenomena associated with an acute inflammation, are usually well marked.

Treatment.—The offending wound or causative lesion must be dealt with by such measures as may be needed to hasten its restoration to a healthy state. Fomentations or poultices are applied over the gland, and the patient, after the administration of a purge, may be given quinine and iron, if necessary. As soon as pus has formed it should be let out by an incision, and the wound dressed antiseptically.

The **Axillary Glands** are usually affected as a result of poisoned wounds of the hand or fingers, although other glands exist lower down in the arm, viz., the supracondyloid, just above the internal condyle. Boils in the axilla and excoriations or infected wounds of the breast may also cause an axillary abscess. In this region a suppurative peri-adenitis is often superadded, extending widely under and between the pectoral muscles, reaching even up to the clavicle (*vide* axillary cellulitis, p. 87). Care must be taken in opening such an abscess to avoid the main vessels by cutting from above downwards, midway between the anterior and posterior axillary folds, whilst Hilton's method should be adopted in all cases where the pus is situated deeply.

In the **Groin** there are three groups of glands: (1) The oblique set, running parallel to Poupart's ligament, and becoming inflamed in affections of the penis, scrotum, perineum, anus, buttock, and lower part of the abdomen; (2) a superficial vertical set, running with the long saphena vein, and receiving lymph from all the superficial parts of the limb, except perhaps those from which the blood is returned by the external saphena vein, the popliteal glands receiving the lymph from this region; and (3) the deep vertical set, receiving the deep lymphatics of the limb. Abscess in the groin is opened by a vertical incision, so as to allow the wound to gape when the patient sits, and prevent pocketing of matter.

Suppuration in the glands of the **Neck** is exceedingly common, arising most often from affections of the scalp (eczema or pediculosis), ear (otorrhœa or eczema), throat, or lips. As to the exact distribution of the lymphatics, we must refer students to anatomical textbooks. When opening a cervical abscess, care must be taken to avoid important structures, such as the external jugular vein, and to make incisions across the fibres of the platysma in order to gain space for efficient drainage.

Chronic Lymphadenitis.—Three chief varieties of chronic inflammation of lymphatic glands are met with—viz., the simple, syphilitic, and tuberculous.

1. **Chronic Simple Lymphadenitis** is a condition resulting from some peripheral irritation, which is insufficient to cause an acute attack. Occasionally it is due to blows or to strains, as in over-walking, being then the outcome of obstruction to the lymphatic flow from compression or rupture of the efferent vessels. The glands become enlarged, tender, and painful, but as a rule they are not adherent to one another or to adjacent structures, and show but little tendency to suppurate. This condition often precedes, and, indeed, may be looked on as a predisposing cause of, tuberculous lymphadenitis. The **Treatment** consists in keeping the part at rest, and removing, if possible, all sources of local irritation. The general health should also be attended to, especially in children predisposed to the development of tuberculous disease.

2. **Chronic Syphilitic Lymphadenitis.**—The lymphatic glands are involved in several ways in the course of syphilitic disease: (*a*) The primary lesion is associated with the development of an indolent bubo in the nearest lymphatic glands (p. 157). (*b*) In the second stage, when general infection has occurred, the glands in many parts of the body are infected in the same indolent fashion (p. 160). (*c*) In

the tertiary period the lymphatic glands may undergo a true gummatous change, or become enlarged and tender owing to the absorption of infective material from a broken-down gumma.

3. **Chronic Tuberculous Lymphadenitis** occurs most commonly in children or young adults, and especially in those whose surroundings are unhealthy, and whose general condition is deteriorated by insufficient or bad food and want of fresh air. Some local focus of irritation is usually present in the form of pediculosis capitis, decayed teeth, chronic otorrhœa, adenoids, or eczema of the face. As a result of this, neighbouring glands become chronically inflamed, and, as the late Sir T. Burdon Sanderson expressed it, ' the soil is thereby prepared for the seed.' The bacilli are conveyed to the gland by the blood or lymph, gaining access through some breach of surface, or even through a healthy mucous membrane; or perhaps they may be derived from some deep focus of quiescent tubercle, say, in the bronchial or mediastinal glands. Any lymphoid tissue in the body may become the seat of tuberculous disease; but the glands of the neck, which derive their lymph from the mouth, throat, nose, ears, and scalp, are more commonly involved than any others. The axillary and inguinal glands are not unfrequently affected, whilst tuberculous disease of those in the mesentery gives rise to the affection known as ' tabes mesenterica.' For the general facts as to the pathology of tuberculosis, see p. 176.

The earliest manifestation of the disease consists in a *fleshy enlargement* of the glands, which cannot at first be distinguished from a simple chronic hyperplasia. The gland may be enlarged to many times its natural size, and on section looks pinkish in colour, and is of firm consistence. Microscopically, all that is noticed is a great increase in the lymphoid corpuscles, together with some overgrowth and thickening of the fibrous capsule and trabeculæ. When tuberculous infection has occurred, the characteristic nodules can be seen under the microscope, but there is at first no change in the naked eye appearances. *Caseation* follows sooner or later, appearing as foci scattered through the gland, which gradually coalesce to constitute larger masses, which may in time involve the whole. Should the case recover without suppuration, the gland gradually shrinks, and becomes small, hard, and often closely adherent to surrounding tissues, whilst the caseous material is absorbed, or undergoes *calcification*. This latter change is often seen in the mediastinal and mesenteric glands, but is not very common in the neck.

More frequently *suppuration* ensues, sometimes from a simple liquefaction of the caseating material, sometimes from a superadded infection with pyogenic organisms. Foci of pus develop at various spots in the parenchyma, and when once formed, these gradually amalgamate and cause the destruction of the rest of the gland. Several of these abscesses may unite one with another, and thus a large multiloculated cavity containing pus mixed with caseous débris is formed. A certain amount of *peri-adenitis* is almost always present, though not to any great extent in the early stages; when, however, suppuration has occurred, the enlarged glands become adherent to one another and to surrounding structures. In the more chronic cases the fibro-cicatricial tissue thus formed may be so extensive as to fix the mass firmly to the deeper parts, such as the main vessels and nerves, rendering removal dangerous and almost impracticable. Important vessels are occasionally eroded by an extension of the suppurative process, and this may lead to fatal hæmorrhage. Sooner or later the abscess, if left to itself, bursts at one or several spots, giving exit to the pus and caseous débris, and leaving ulcerated openings, which are surrounded by skin that is undermined, thin, and purplish, and through which granulations protrude. A variable amount of pus escapes from these until all the caseous material has disappeared, so that the condition may persist for many years before healing occurs, and even then the *cicatrix* is often puckered and more or less keloidal, and may retain its vascularity for a much longer period than would a healthy scar. Lymphatic œdema in the region drained by the affected glands is sometimes observed as a late consequence of this affection.

Treatment in the early stages consists mainly in improving the general health by means of suitable diet and tonics, such as cod-liver oil and syrup of the iodide of iron, together with residence in a healthy, bracing place, especially at the seaside or on high moorland. All sources of local irritation, septic roots of teeth, enlarged tonsils, adenoids, etc., must be removed so as, if possible, to prevent infection with pyogenic organisms; and counter-irritants, such as iodine paint, are best avoided. Rest of the affected part should be enforced as much as possible; in some cases the application of splints to restrict movement is advisable. Small doses of tuberculin are often useful (p. 184).

Operative Treatment.—Too much time should not be wasted in palliative measures, inasmuch as the longer the glands are left, the firmer will be the adhesions which they are likely to contract to surrounding tissues, and the more difficult the dissection for their removal. Operation is indicated when the glands persist in spite of suitable care, and still more if they enlarge or show evidences of suppuration.

In the *neck* every effort must be made to avoid operation, but it is well to remind patients or their friends that the scar of an aseptic operation is less obvious than that which follows the opening of an abscess and the scraping out of a gland. When *abscesses* form, it must be remembered that there is frequently a deep sub-fascial origin, communicating with the superficial subcutaneous collection of pus by a narrow aperture; unless this deep focus is dealt with efficiently, the wound will not heal. It may sometimes be practicable to scrape away all the deep tuberculous material at the time that the abscess is opened; but, failing that, the wound is allowed to heal as far as possible, and then at a later date the whole mass of glands involved in the process is removed. When *extirpation* of glands is required, the incision varies with the situation of the mass, but every precaution is taken to minimize the deformity and scarring. In the upper part of the neck, when the glands lie in front of the sterno-mastoid, an almost transverse incision may be employed, or one following the creases of the skin and very similar to that for ligature of the lingual artery (Fig. 122, B). In the lower half of the neck an incision along the anterior or posterior border of the sterno-mastoid (E) will often suffice, or if the glands extend backwards a transverse one just above the clavicle (A^1).

When enlarged glands are present both in front of and behind the sterno-mastoid, as well as beneath it, their removal is perhaps most satisfactorily accomplished by a method suggested by Halstead. The incision commences close to the tip of the mastoid process, and, passing forwards just behind the jaw, sweeps across the neck to the middle of the clavicle (Fig. 122, A); a second incision runs transversely just above the clavicle (A^1). The flaps thus marked out are dissected up so as to lay bare the sterno-mastoid and the enlarged glands. The deep dissection commences from below and behind. The supraclavicular triangle is first cleared, the omo-hyoid muscle being divided, but sutures are left on the ends for identification. The anterior end is drawn up, and serves to raise the sterno-mastoid, which is then divided obliquely (D) below the spinal accessory nerve (C). The divided ends are turned up and down so as to expose freely the glands lying on the carotid sheath, which are dealt with from below upwards. Special care must be taken of the nerves and of the internal jugular, but it is better to tie and remove this structure than to leave it in the wound with a number of lateral ligatures applied, which might possibly be forced off by the suddenly increased intravenous tension induced by the post-anæsthetic vomiting. When all the glands have been removed, the divided muscles are carefully replaced and sutured together, and divided fasciæ, etc., approximated by buried sutures. In this, as in all neck operations, the skin is brought together by Halstead's intradermic suture, and it is wonderful how little scarring and deformity follow this extensive procedure.

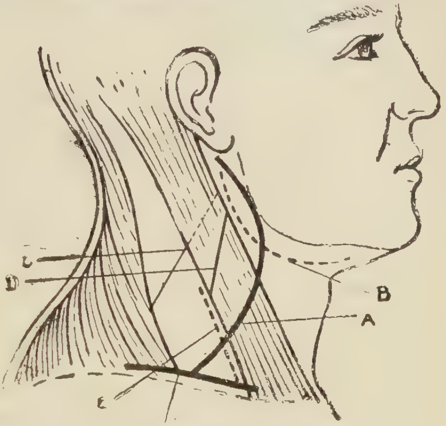

FIG. 122.—INCISIONS FOR REMOVAL OF TUBERCULOUS GLANDS FROM THE NECK.

A and A^1, For removal of glands from both triangles (Halstead's method); B, for removing glands from submaxillary and upper carotid regions; E, for removing glands in lower part of posterior triangle; C, spinal accessory nerve; D, site for division of sterno-mastoid.

The *pre-auricular gland* lying on the capsule of the parotid is sometimes affected, and may cause facial paralysis, either as a result of the sclerosing peri-adenitis, or from injudicious surgery. Any incisions made with a view to remove the gland or to open an abscess therein should be made in the direction of the fibres of the facial nerve—*i.e.*, horizontally.

In the *groin*, tuberculous glands are often mistaken for some condition due to venereal disease. The history of onset and the extreme chronicity should suffice to establish a diagnosis. The iliac glands will often be found similarly affected, and operations in this region are sometimes very extensive in consequence. Well-marked periadenitis is usually present in the iliac fossa, and the glands may be very adherent. Atrophy of the testicle sometimes follows, either from division of the spermatic vessels, or from their implication in the cicatrix.

Tumours of Lymphatic Glands.

Lymphadenoma, or **Hodgkin's disease,** is characterized by a progressive enlargement of the lymphatic glands and of the lymphoid tissue of the spleen, liver, and other organs. The affected glands and the masses in the viscera are quite characteristic in structure, and have a very different appearance from that seen in simple hyperplasia or in infective processes. The gland is homogeneous on section, the distinction between cortex and medulla being lost. The amount of stroma varies considerably, and the glands are hard or soft according to its relative abundance or not. One type does not appear to pass into the other, and the soft form is, in most cases, more malignant and more rapid in growth than the hard. There is a relative decrease of lymphocytes in the glands, and an increase in the endothelial elements, some of which are multi-nucleated. Nothing is known as to its cause, but it is probably an infective disease.

Hodgkin's disease is most common in young adults, but no age is exempt; it is decidedly more common in males than in females. In some cases the cause of the original enlargement of glands is some inflammatory lesion, such as otitis media or dental caries, but often no such origin can be traced. The glands first affected are usually the cervical, and the disease may remain limited to a larger or smaller group of these for a considerable time before other manifestations show themselves; this condition is sometimes termed *benign or localized lymphadenoma*. In other cases internal glands become affected first, and this most commonly in the mediastinal group, the retro-peritoneal glands coming next in order of frequency. When the disease is more advanced, lymphadenoid tissue in any part of the body may be affected. The spleen is usually somewhat enlarged, and in about half the cases presents localized grayish-white tumours (the *hard-bake spleen*). Similar growths may occur in the liver, kidneys, etc., or in the skin.

The early symptoms are slight, the only thing noticed being the glandular enlargement. In this stage the glands are soft and elastic, and not adherent to the skin or to one another; they have little or no tendency to caseate or suppurate. When the internal glands are first affected, the earliest symptoms may be those of pressure. This is most marked in the mediastinal group of cases, in which pressure on the superior vena cava is early noted, leading to engorgement of the superficial thoracic veins.

In the later stages intermittent febrile attacks appear, associated with swelling and pain in the glands, possibly due to a superadded mild pyogenic infection; periadenitis results, and the glands often fuse together, forming hard masses of large size, whilst the disease becomes generalized. The blood shows a moderate grade of anæmia of the secondary type, with a slight increase of leucocytes, especially of the lymphocytes. Gradually the pyrexia becomes more constant, and the patient passes into a cachectic condition.

Diagnosis.—(1) From *lymphatic leucocythæmia* (pp. 65, 67) Hodgkin's disease is recognized by the entire absence of blood changes in the early stages, and by the presence merely of a secondary anæmia in the later. Moreover, lymphadenoma usually limits itself to regions in which adenoid tissue is normally present; leucocythæmia may develop new growths in any part of the body. (2) From *lympho-sarcoma* it is known by the fact that it is almost invariably limited to the glands, and does not infiltrate surrounding tissues. Lympho-sarcoma is characterized chiefly by its tendency to infiltrate, and also by producing secondary deposits in tissues which are not rich in adenoid tissue. (3) From *tuberculous disease* of glands the diagnosis is often difficult. Tubercle is more common in the very young, and is more frequently bilateral. The glands have a greater tendency to fuse together as a result of periadenitis, and to suppurate. In doubtful cases microscopic examination of an excised gland may be required to settle the diagnosis.

The *Treatment* of Hodgkin's disease is, as a rule, most unsatisfactory. In the earlier stages removal of the enlarged glands is easily effected, but recurrence is the usual result. In the later stages, when several attacks of inflammation have occurred, removal may be most difficult. Probably the best treatment consists in the administration of arsenic and the exposure of the enlarged glands to X rays. Arsenic must be administered in large doses for some considerable time, or possibly salvarsan may be substituted for it. In one case recently treated the happiest results followed the administration of one dose of 0·6 gramme salvarsan and X rays; several previous operations had been followed by relapse.

Lymphatic Leucocythæmia is of little surgical interest except in so far as it simulates Hodgkin's disease. The symptoms are much more severe than in the latter, and marked blood changes are present; the number of the leucocytes is enormously increased, reaching 150,000 or more per cubic millimetre, and there is a great preponderance of lymphocytes, which constitute from 90 to 99 per cent. of all cells present. There is also anæmia, often of some severity (pp. 65 and 67). Arsenic is valuable, and operative treatment useless. Recently X-ray treatment has been employed to the spleen and ends of the long bones with temporary benefit.

Lympho-Sarcoma.—This term has been used with very different meanings, but is best restricted to tumours which have a structure approximating to that of lymphadenoid tissue—*i.e.*, which consist of small round cells, resembling, if not identical with, ordinary lymphocytes, set in a reticulated stroma; there is no distinction between cortex and medulla. They closely resemble a small round-celled sarcoma, except that the stroma is more obvious; their sarcomatous nature is evidenced rather by clinical than by histological characters—viz., by the fact that they invade and destroy surrounding tissues.

Lympho-sarcoma may commence in any part of the body, but in the vast majority of cases it originates in pre-existing adenoid tissue, most commonly in the glands at the root of the neck, the tonsil, or the mediastinum. It may also affect the intestines (commencing probably in the Peyer's patches) or the testis. When commencing in a region where its development can be followed, it is seen to form a rapidly-growing tumour, which is at first firm, elastic, and painless; later on, however, as it increases in size, it becomes tender, and may cause great pain from pressure on, or implication of, nerves. It early contracts adhesions to surrounding parts, and gives rise to secondary growths in neighbouring glands by direct transmission. The superjacent skin is at first unaltered in colour and texture, but as the tumour increases, it becomes congested and shiny, and contains a network of dilated veins. Finally, ulceration occurs, and is followed by the sprouting up of a bleeding fungating mass, similar in character to that formed by any other rapidly-growing malignant tumour. Dissemination of the growth throughout the viscera follows, death resulting from exhaustion and cachexia.

The *Treatment* consists in the removal of the mass, where practicable, without delay. If, however, extensive adhesions exist, this becomes absolutely impossible, and radio-therapy can alone be relied on.

Secondary Growths in Lymphatic Glands are a special feature of all cancerous tumours. In the sarcomata they are less common, but are always present in the case of melanotic sarcoma, lympho-sarcoma, and usually in sarcoma of the testis, tonsil, and thyroid. The special characteristics of these are noted elsewhere.

CHAPTER XVI.

AFFECTIONS OF NERVES.

THE simplest and most common forms of injury to which nerves are liable are **Contusions** and **Strains,** causing a sensation of tingling, or pins and needles, which usually wears off in the course of a few hours. In severe cases variable degrees of loss of power and sensation may ensue, and in hysterical women more or less neuralgia. In patients suffering from gout, syphilis, or rheumatism, a chronic peripheral neuritis is readily induced, often of a somewhat intractable type, and this even develops in healthy individuals. **Treatment** consists in gentle friction with stimulating liniments.

Compression of a nerve is usually due to the presence of a tumour or aneurism, or to some displacement or inflammation of bones; in fractures a nerve may be included in the callus formed in the process of repair, the symptoms not appearing till four or five weeks after the injury; or it may be met with in the form of crutch palsy, or as a result of splint pressure. The early symptoms are those of irritation, *e.g.*, cramp, and spasm of muscles or neuralgic pain; whilst later on paralysis and anæsthesia appear, combined sometimes with trophic phenomena. If the compressing cause can be removed, recovery, at any rate of a partial character, follows in time under suitable treatment, such as massage and electricity.

Rupture of nerves without an external wound only occurs in connection with severe injuries, such as dislocations or fractures, and even then total division is rare, the sheath retaining its integrity, although the axis cylinders may have given way. Immediate paralysis and loss of sensation usually follow, and may persist for a time, although repair not unfrequently occurs, since the sheath remains intact. The doubt always existing as to the condition of the sheath regulates the **Treatment** which must be followed, viz., one of expectancy. Friction and electricity should be applied to the parts, and only when these have failed should operation be undertaken. Secondary nerve suture under these circumstances is not a very successful proceeding.

Total Division of a Nerve.*—The **Immediate Effects** are: (*a*) Paralysis of the muscles supplied by the nerve; (*b*) complete anæsthesia of the parts supplied by it, which, however, is not necessarily permanent, since sensation may be conveyed by collateral trunks, the anæsthetic area passing through gradual stages of partial sensation before recovery is complete. (*c*) Vasomotor paralysis is also produced, the limb becoming hyperæmic and warmer for a few days. and then subsequently colder and insufficiently supplied with blood, (*d*) The excito-secretory nerves are paralyzed so that glands lose their functions for a time.

The **Secondary Effects** vary with the character of the nerve injured, and are much more complicated than the former.

1. **Changes in the Nerve.**—*Locally*, the two ends retract very slightly, perhaps not more than the twelfth of an inch, and the space thus formed fills with blood, which is quickly absorbed and replaced by granulation tissue, and this in turn by a bulb-like mass of fibrocicatricial tissue (*traumatic neuroma*), within which are found spaces filled with fine nervous fibrillæ coiled up in loops. After an amputation, most of the divided nerves are found to have developed these typical bulbous ends (Fig. 123), whilst in nerves accidentally severed in their continuity the bulbous mass which forms on the upper end is separated by an interval from the atrophied lower end, though there is usually a fibrous connection between the two. These bulbs are often the seat of severe neuralgia. In a few rare instances immediate union of a divided nerve is supposed to have occurred, as indicated by total and rapid restoration of function.

Peripherally, the so-called Wallerian degeneration commences about the fourth day after the accident, in consequence of the separation of the nerve from its trophic centres. It first shows itself in the medullary substance, which undergoes a form of segmentation, becoming broken up into irregular masses of myelin, which are absorbed by leucocytes or connective-tissue cells, and disappear entirely in about a month. The axis cylinders also degenerate and disappear. The neurilemma cells proliferate in columns and form a fibro-cellular rod, which represents the nerve, and early loses all power of conducting nervous or electric stimuli, although attempts at regeneration are made at both ends.

Proximally, degeneration of the medullary sheath occurs, similar to that which is seen in the distal portion, but only extending as far as the next node of Ranvier. It is of but little significance.

2. **Changes in the Muscles.**—Complete paralysis of motion necessarily occurs when a motor nerve has been divided, and the muscles involved slowly waste and undergo degeneration. The atrophy is not noticed at first, and is not so rapid as that arising from infantile palsy, since it is simply due to separation from the trophic centres, and not to their destruction. Deformity may ensue, owing to the

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* For an elaborate investigation of this subject, see Head and Sherren on 'The Consequences of Injury to the Peripheral Nerves in Man,' in *Brain*, Summer Number, 1905, part cx.

unbalanced action of opposing groups of muscles. The *electrical* changes, too, are important. The faradic current rapidly loses its power over the paralyzed muscles, and its effects totally disappear in two or three weeks, whilst the galvanic excitability remains for weeks or months, and even then only slowly diminishes, so that a condition develops in which the galvanic current produces a much greater contraction than the faradic (*reaction of degeneration*, p. 51). As long as this phenomenon remains, there is a hope that restoration of the continuity of the nerve may be followed by restoration of function; but when the muscles react neither to galvanic nor to faradic stimuli, the case may be looked upon as beyond repair.

3. Various modifications of **Sensation** are produced. Head and Sherren* have demonstrated that different types of sensory impulse are carried by separate groups of nerve-fibres, and that the peripheral distribution of these varies considerably. (*a*) *Deep* sensation consists in the appreciation of pressure, including heavy touch and painful pressure, and in the recognition of the positions and movements of joints and muscles. These stimuli are carried by motor nerves, and distributed to muscles, tendons, ligaments, etc. Section of all the sensory nerves to the skin of a part does not destroy this form of sensation. (*b*) *Protopathic* sensation takes cognisance of painful cutaneous stimuli, and of the effects of temperatures below 20° and above 50° C. The distribution is somewhat indefinite and diffuse, following rather the nerve-root areas than those of the peripheral nerves. The superficial extent supplied by a particular nerve is only recognised when all other sensory nerves to the part are divided (Figs. 124 and 125). The overlapping of these areas will explain the persistence of certain forms of sensation when the nerve apparently supplying that area has been divided. (*c*) *Epicritic* sensation includes the appreciation of light touch (as by a wisp of wool), the localization of stimuli, the recognition of moderate degrees of temperature (between 20° and 40° C.), and the power of discriminating between two stimuli simultaneously applied, as by the points of a compass; its distribution corresponds with fair accuracy to that of the peripheral nerves.

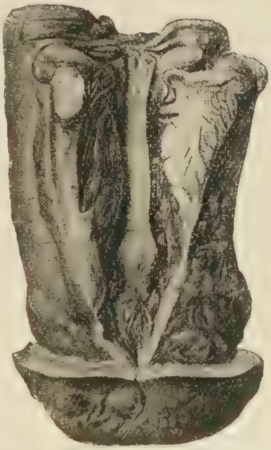
FIG. 123.—TRAUMATIC NEUROMA OF POSTERIOR TIBIAL NERVE AFTER AMPUTATION OF LEG. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

Section of a purely sensory nerve causes loss of the epicritic and protopathic forms of sensation only, but the area over which the epicritic sense is lost is greater than that over which protopathic sensation is absent, owing to the overlapping of neighbouring nerve areas. Section of a mixed nerve causes loss of all three types of sensation in any area exclusively supplied by that nerve, but if there is much anastomosis with neighbouring nerves protopathic sensation is little affected. Section of a posterior nerve-root affects protopathic sensation more extensively than the epicritic. In incomplete division or injury of sensory nerves, epicritic sensation is abolished more extensively than protopathic.

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* *Op. cit.*, James Sherren, 'Injuries of Nerves and their Treatment,' 1908.

4. The blood-supply to a paralyzed part is diminished, and the circulation feeble; hence the extremities usually become cold and their vitality lowered. Chilblains are readily produced, and the unwise application of heat may cause blistering or even sloughing; wounds heal badly, and ulceration from slight irritants is very likely to occur, *e.g.*, corneal ulceration after division of the fifth nerve, and perforating ulcers of the foot. Atrophy of the smaller bones may follow, and ankylosis of the terminal joints of the fingers or toes. In a growing child the development of the part is always more or less impaired. If, however, the nerve is partially divided and the ends irritated, more serious changes occur. The skin becomes thin, atrophic, bluish-red, and shiny (' glossy skin ' of Weir Mitchell), or it may be rough and covered with scales, or even œdematous. The cutaneous appendages are also involved, the hairs falling out, the nails becoming rough, brittle, and scaly, and the sebaceous and sweat glands either discharging an abundant secretion, or remaining absolutely functionless.

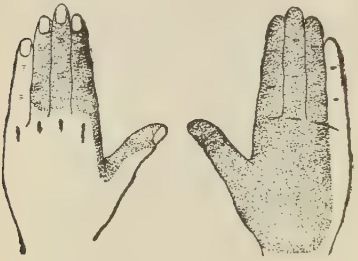

FIG. 124.

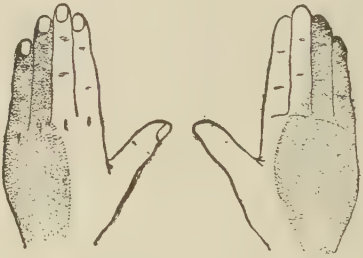

FIG. 125.

Fig. 124 indicates the area of protopathic sensation supplied by the median nerve, as determined by section of all other sensory nerves to the hand.
Fig. 125. Ditto for ulnar nerve. (After Sherren.)

5. In a few cases changes have developed in the central nervous system which are of much interest. In the early stages reflex spasms or paralyses are sometimes met with as temporary phenomena; but at a later date more serious symptoms may result. Thus, in a glass wound of the median nerve, a healthy man treated at hospital developed a typical epileptic fit whenever the neuralgic bulbous end was touched. The bulb was excised, and the nerve cleanly sutured, but without effect, the epilepsy and pain still remaining.

The median nerve was divided above the elbow, and a portion removed, but without benefit. Finally, the patient passed into a condition of chronic dementia, and died, no obvious lesions being found on post-mortem examination.

Regeneration of a divided nerve must necessarily occur if restoration of function is to be obtained. Attempts at regeneration are always evident in the distal segment, whether or not it has been sutured to the upper end, but in the latter case the phenomena are later in appearance and are never carried to perfection, owing to the intervention of the end-bulb. Considerable discussion has arisen as to whether the new axis cylinders grow downwards from the central end to the peripheral, or whether they are developed *in* the distal segment. Ballance and Purves Stewart, who favour the latter theory, state that the proliferated neurilemma cells always retain their longitudinal direction, and that about three or four weeks after the division (a little later, if no operation) thin beaded threads begin to show themselves along one side of such a spindle-shaped cell, and, gradually growing downwards, stretch out towards their nearest neighbours. The union of these small segments constitutes the new axis cylinder, which is gradually covered in by a medullary sheath, also apparently the product of the neurilemma cells, and finally joins with the central end of the nerve. Halliburton and Edmunds, and others of the opposing school, teach that regeneration of the axis cylinders always proceeds from above downwards, the new fibrillæ forcing their way down along the sheath of the nerve, and look on the changes in the peripheral end as merely preparatory—and this opinion is probably correct. In any case the process is slow and takes many months to reach completion. Clinically, the earliest evidence of regeneration is a slight return of sensation, which is at first protopathic, and only slowly becomes of an epicritic type. Motion is generally much later in its restoration than sensation, and may never be entirely recovered. Under very favourable circumstances it is possible for an interval even as great as 1½ inches to be bridged over by this process, but such an event is very unusual. The use of a nerve-graft under these conditions may direct the energies of the neuroblastic cells, but the graft is itself quite passive.

The **Treatment** of a divided nerve depends upon its size and function. If small and of slight importance, no special treatment is required; but any of the main nerves of the extremities must be dealt with at once by **Primary Nerve Suture.** This is best accomplished by using a domestic sewing needle without cutting edges, or a fine Hagedorn needle, and the finest catgut; one or more stitches should pass through the nerve, and the rest merely through the sheath. Absolute asepsis is essential in order to obtain satisfactory results. It is most desirable that the nerve should be protected from the pressure of adhesions by wrapping it in gold beater's skin or Cargile membrane. In wounds involving the nerves about the wrist the deep fascia should also be carefully sutured to prevent the formation of adhesions between the nerves and tendons to the skin, whereby subsequent mobility would be impaired.

If the wound has been inflicted months before, and a bulb has formed, **Secondary Nerve Suture** must be employed. The nerve is first exposed by a free incision through the cicatrix, the two ends identified and isolated, and the fibrous tissue of the bulb removed to a sufficient extent to expose healthy nerve fibrillæ; the divided ends are then brought together with as little tension as possible. To bridge the gap traction upon each end of the nerve may be employed to stretch it, and the limb subsequently placed in such a position as to relax the parts—*e.g.*, the wrist flexed to a right angle, or the elbow bent (except when dealing with the ulnar nerve above the elbow, flexion of which increases the tension on the nerve). Resection of a segment of bone may be justifiable in certain cases to allow the divided ends to be approximated.

Nerve-grafting, in order to bridge over a defect, has not up to the present been followed by much success. A nerve similar in size to that to be operated on is removed from an animal just killed, and carefully stitched in position. Since it merely acts as a carrier to the neuroblastic cells, the same result would possibly be obtained by passing several fine strands of catgut from one end to the other.

Nerve-anastomosis has been utilized in a few cases of facial paralysis, and in a few other instances in order to restore movement. A suitably-placed motor nerve is laid bare, and either the whole trunk or a portion of it united to the divided end of the affected nerve; in time motor phenomena have manifested themselves with some degree of benefit.

During the time that the paralysis continues, the limb must be massaged, the fingers or toes worked daily to keep them from getting stiff, and the muscles treated with electricity, and preferably by means of the electric bath, one electrode being placed in a basin of warm saline solution, and the other against the patient's back, and the affected limb dipped in the water till it becomes of a bright red colour. In the intervals the paralyzed muscles should be kept relaxed by suitable splints or apparatus so as to prevent overstretching by opposing unbalanced muscles, which would subsequently impair their utility. Anæsthetic parts must also be protected from pressure.

In many cases where the original wound has been complicated by suppuration the impaired mobility is as much due to the inflammatory adhesions of joints and tendons as to paralysis.

Acute Neuritis is not very common. It is usually due to injury, gout, or rheumatism, but is occasionally observed in connection with infected wounds. The nerve may sometimes be felt to be swollen or tender, whilst severe pain of a neuralgic type is often experienced. On microscopic examination the ordinary signs of inflammation are well marked, though mainly in the sheath. The **Treatment** consists of rest to the limb together with leeching or dry-cupping over the course of the nerve, combined with belladonna fomentations and suitable general therapeutic measures.

Chronic Neuritis, or **Perineuritis,** is much more common than the former. It consists pathologically in an increase of all the connective tissue of a nerve, both around it and between the fasciculi, with compression of the vessels and nerve-fibres. It may result from injury, such as sprains, strains, or pressure, especially when the patient is suffering from syphilis, rheumatism, or gout, and is met with after influenza and in various toxic conditions, *e.g.*, alcoholism, diabetes, malaria, etc. It is very common in the fifth nerve, and in the branches of the brachial plexus. The **Symptoms** vary a good deal with the nerve affected, which can occasionally be felt thickened and tender on pressure. More or less severe neuralgia results, accompanied by loss of power in the case of a motor or mixed nerve. Trophic lesions may also be induced, such as perforating ulcer, or ankylosis of the terminal joints of fingers or toes.

The **Treatment** in the early stages consists in the administration of anti-diathetic remedies, and, indeed, iodide of potassium, with or without mercury, is generally applicable. Locally, prolonged rest is needed, with counter-irritation in the form of blisters, and later on massage. If there is any paresis, the muscles must be stimulated daily by the faradic current or electric bath; radiant-heat baths are also valuable, and ionic medication. Pain is combated by aspirin or other drugs, or by administering hypodermically morphia or atropine. Failing these, acupuncture may be adopted, in which needles are passed into the substance of the nerve, and allowed to remain for a few moments; this probably acts by relieving the inflammatory tension within the sheath. Various operative measures dealt with under neuralgia may be called for in severe and protracted cases.

For **Tumours** of nerves, see p. 212.

Neuralgia is a condition which either the physician or the surgeon may be called upon to treat; it is exceedingly common, and may be one of the most terrible afflictions to which the human frame is subject. It is characterized by paroxysmal or intermittent pain of a darting or stabbing type, which follows the course of some particular nerve or nerves, especially the trigeminal. The attack usually commences suddenly, and the pain steadily increases until it reaches a climax, and then gradually or rapidly subsides. These paroxysms may last minutes or hours, and may recur at varying intervals, either a few in a day or many in an hour; they may be induced by sudden noises, a draught of air, etc. Moreover, pressure over the affected trunks may originate, relieve, or increase the pain, whilst the skin affected by them is often intensely tender, and even hyperæmic and œdematous (the *points douloureux* of Valleix). Occasionally adjacent muscles become spasmodically and sympathetically contracted during the attack, whilst excessive secretion, such as from the lachrymal or sweat glands, is also induced. Herpes is sometimes met with in the area of distribution of the affected nerve (*e.g.*, shingles in connection with intercostal neuralgia). Neuralgic manifestations may occur in any sensory or mixed nerve, such as the intercostals or sciatic, or in complex bodies, such as the breast, testis, or the larger joints.

The **Causes** of neuralgia are very diverse, and the surgeon often has to look far afield in order to find them. Thus, as *predisposing* causes may be mentioned the hysterical temperament, anæmia, and depressing circumstances of all kinds, especially mental anxiety and worry. The *direct* causes may be toxic—*e.g.*, malaria, influenza, lead, or mercury; reflex—*e.g.*, ovarian disease, worms, etc.; central, from disease of the spinal cord or brain; radical, from pressure on the nerve-roots as they emerge from the spinal canal or cranium; or peripheral, owing to lesions of the trunks induced either by trauma, inflammation, or new growths.

In the absence of any recognisable or remediable cause, **Treatment** consists primarily in attention to the general health, and the local application of counter-irritants and sedatives. Iron and arsenic may be given to anæmic patients; anti-spasmodics, such as valerianate of zinc, to hysterical women; quinine or arsenic for malaria; whilst sea-bathing or change of air is often advisable. Iodide of potassium and mercury are beneficial in all cases due to syphilis. When the pain is excessive, morphia, even in large doses, may be required. Empirical remedies, such as aspirin, antipyrine, phenacetin, menthol, and croton-chloral hydrate will sometimes do good. Neuralgia is a favourable field for hydro- or electro-therapy, or for ionic medication (p. 54) with cocaine or other drugs.

When, however, medicinal agents fail, surgical measures are indicated in order to allay the patient's sufferings. The following are the more usual methods adopted:

1. **In purely Sensory Nerves,** such as the trigeminal, destruction of the nerve tissue by the injection into the trunk of alcohol (70 per cent.) has been much used recently. Simple division or *neurotomy* has often been resorted to, but the relief gained is of a most temporary nature, since sensory nerves readily unite after division, and sensation is rapidly restored; hence the operation has fallen into discredit. A more satisfactory proceeding is *neurectomy*, or the removal of a portion of the nerve trunk, which does temporary good even in cases due to central causes, probably by placing the centre in a condition of rest through the exclusion of afferent stimuli. As large a portion of the affected nerve should be removed as possible, and Thiersch suggested a plan of *nerve-extraction* in which the trunk is laid bare at a suitable spot, and then grasped with forceps and twisted out.

Finally, if all such measures have failed, the roots of the nerves may be divided either within the skull or in the spinal canal, or the ganglia connected with their roots may be removed.

2. **In a Mixed Nerve,** conveying motor as well as sensory stimuli, *nerve-stretching* has to be mainly relied upon. The trunk is laid bare,

and traction exercised, both centrally and peripherally, by means of a blunt hook if the nerve is small, or by the finger placed under it if large. The clinical effect is to abolish the conductivity of the nerve for a time, either completely or partially; but since it is not divided, repair and restoration of function follow. The elasticity and extensibility of the nerves are considerable, and the force needed to cause their rupture has been accurately estimated. It varies much in different individuals, and allowance must be made for this in all operations. Thus, the sciatic nerve will stand about as much traction as an ordinary man can make with his finger and thumb; it should be applied steadily and continuously, not in a series of jerks. The effect of stretching is to free the nerve from external inflammatory adhesions, and to alter the relations between the sheath and its contents. The perineurium has its fibrillæ, which are naturally wavy, straightened out, thereby compressing the lymphatic spaces between the fibres, and possibly rupturing the nervi nervorum. The nerve becomes hyperæmic, and the medullary sheath of the tubules may be irregularly broken up.

Affections of Special Nerves.

The Cranial Nerves.—The **Olfactory Nerve** may be involved in fractures extending across the cribriform plate of the ethmoid, or in severe cases of contusion of the anterior lobes of the brain without fracture, resulting in loss of smell (anosmia).

The **Optic Nerve** is sometimes ruptured in fractures of the base of the skull running into the optic foramen, or divided by penetrating or bullet wounds, leading to sudden irremediable blindness; or it may be compressed by effused blood or inflammatory exudation, either within or outside of its sheath, causing more or less complete loss of vision; if the hæmorrhage has not been very extensive, vision may be in measure restored. Orbital cellulitis not unfrequently causes pressure on the nerve, either immediately as a result of the inflammation, or subsequently by cicatricial contraction. Syphilitic disease of the sheath, or the formation of a gumma in its neighbourhood, or intra orbital aneurisms or tumours, may likewise interfere with vision from pressure on the trunk. Optic neuritis (p. 776), or more accurately papillœdema, is an œdematous condition of the intra-ocular termination of the nerve in the fundus oculi, due to increased tension of cerebro-spinal fluid; it is a frequent result of cerebral tumours or inflammation, and is generally followed by optic nerve atrophy and blindness.

The **Third Nerve** (*motor oculi*) being entirely motor, paralytic symptoms are those to be looked for. They may arise from *central* causes, such as syphilitic or degenerative changes in the floor of the third ventricle; or from *peripheral* lesions, such as aneurisms, tumours, gummata, trauma, etc., either in the orbit, sphenoidal fissure, or base of the skull. The **Symptoms** of complete paralysis are as follows: (*a*) Ptosis, or drooping of the upper eyelid, from loss of power in the levator palpebræ; (*b*) external strabismus, or squint, from paralysis of the inner, upper, and lower recti, the eye being also directed a little downwards from paralysis of the inferior oblique; (*c*) mydriasis, or dilatation of the pupil, from palsy of the iris; (*d*) loss of accommodation, from the ciliary muscle being paralyzed; and (*e*) some slight protrusion of the eyeball (exophthalmos), owing to most of its muscles being flaccid and relaxed. Diplopia is the most marked functional result. In consequence, however, of its close proximity to the fourth, fifth, and sixth nerves in the walls of the cavernous sinus and sphenoidal fissure, symptoms referable to these trunks are often associated with the above, as also venous congestion of the eye and orbit from pressure on the sinus. Should the eyeball be totally immobilized from paralysis of all its muscles without venous congestion, the condition is known as 'ophthalmoplegia externa,' and is always due to central disease affecting the floor of the third ventricle, and probably of syphilitic or tabetic origin. The **Treatment** in most cases consists in the administration of mercury and iodide of potassium.

Paralysis of the **Fourth Nerve** (*Pathetic*), which supplies the superior oblique muscle, results in defective movement of the eyeball downwards and outwards, with diplopia on attempting to look down.

The **Fifth or Trigeminal Nerve** is occasionally torn in head injuries, giving rise to anæsthesia, with perhaps ulceration of the cornea; but such cases are exceedingly rare. Much more common is the affection known as *trigeminal neuralgia*, or tic-douloureux, which occurs in old people, particularly women. It is to be distinguished from the simpler forms of neuralgia due to some local irritation or general weakness by the paroxysmal character and violence of the pain; hence the term 'epileptiform tic' has been applied to it, and not inaptly represents its terrible nature. As a rule it commences in the infra-orbital or inferior dental branches, radiating thence to all the other divisions of the nerve. The paroxysms are not very frequent at first, but they increase both in number and severity, until at last the patient, utterly prostrate, either becomes a morphia habitué, or may even attempt suicide. The condition is often influenced considerably by the general health, and intermissions of varying length occur. The attacks are accompanied by twitching of the muscles of the face, and even of the neck; also by unilateral sweating and hyperæmia of the head, and the development of such marked 'points douloureux,' that possibly the patient cannot brush her hair or wash her face on the affected side. Lachrymation is a marked feature during the attacks, and the secretion of saliva or of nasal mucus may be increased.

The **Cause** is unknown; in a few cases tumours of an endotheliomatous character have been found involving the Gasserian ganglion, but in the great majority nothing abnormal can be found either in the ganglion or its branches.

In the **Treatment** of epileptiform tic all sources of reflex irritation should be relieved or treated, such as carious teeth, errors of refraction, intranasal trouble, ovaritis, etc. A word of warning is needed against the wholesale extraction of healthy teeth for this affection, which may, indeed, be aggravated rather than improved by such treatment. The various analgesic remedies will, of course, be employed, but morphia is often the only drug that gives relief. In most cases **Operative Measures** sooner or later are required. Alcohol injections* by Schlösser's method is reported to give good results, but further experience is required to demonstrate the permanence of the relief from pain. Neurotomy and nerve-stretching only give temporary relief, and excision even of large portions of the nerve-trunks is frequently followed by recurrence. The only procedure that holds out any certain hope of cure is removal of the Gasserian ganglion, or, at any rate, of its lower half; the facts that the first division of the nerve is not often involved in trigeminal tic, that the nutrition of the eyeball is largely dependent on the maintenance of its nerve-supply, and that the upper part of the ganglion is intimately adherent to the outer wall of the cavernous sinus, have determined the practice of leaving intact the ophthalmic portion of the ganglion in the majority of cases. The results of this operation have been very gratifying, and have improved with increased practice and modern methods. At the same time it must not be looked on as devoid of operative dangers or risks; and hence, if the neuralgia is definitely limited to one division only, injection with alcohol, or an intra- or extra-cranial neurectomy is advisable before attacking the ganglion; recurrence after such an operation, or the primary involvement of two divisions, indicates the major operation.

The *Supra-orbital Nerve* does not very commonly require operation, since neuralgia of this trunk is usually distinct from epileptiform tic, and more amenable to therapeutic measures. The pain often recurs about the same time each day (hence the term *brow ague*), and may be treated by giving a pill containing ferri sulph. 1 grain, quininæ disulph. 2 grains, and morphin. hydrochlor. $\frac{1}{12}$ grain, four hours before the attack is expected, and repeating it every hour till six pills in all have been taken. Should the pain persist, neurectomy may be undertaken. The nerve emerges from the orbit through the supra-orbital notch, lying at the junction of the inner and middle thirds of the upper margin ; it is reached by an incision following the course of the eyebrow, through which the orbicularis is divided along the line of its fibres (Fig. 126, *a*). By incising the periosteum and depressing it, together with the orbital fat, the nerve can be followed back for some distance, and a considerable portion removed.

The *Infra-orbital Nerve* emerges from the foramen of the same name at a spot about $\frac{1}{2}$ inch below the centre of the lower margin of the orbit. It can be reached and divided by a horizontal or curved incision placed over this site (Fig. 126, *c*); but since such an operation is unlikely to give more than temporary relief, *the root of the second division* should be at once attacked if operative procedures are necessary. It is most desirable to divide the nerve behind Meckel's ganglion, and hence the operations which are performed from the face (either Wagner's, which follows the floor of the orbit, or Carnochan's, which traverses the antrum) are objectionable, whilst they are almost certain to leave ugly cicatrices (Fig. 126, *d*).

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* For details and methods of injecting the various branches of the fifth nerve, see Purves Stewart, *Brit. Med. Journ.*, September 25, 1909.

The *pterygoid*, or, as it is called, the Braun-Lossen operation, is without doubt the best extracranial method for dealing with the root of the second division. A flap of skin and subcutaneous tissue is dissected forwards from the side of the face (Fig. 105, B), so as to expose the zygoma, which is cleared, sawn through back and front, and turned down together with the masseter. The temporal tendon is thereby exposed, and by drawing this back, and if need be removing the coronoid process completely or in part, it is possible to see into the pterygo-maxillary fossa, and to hook up the root of the second branch of the trigeminal as it emerges from the foramen rotundum and divide it. By severing the nerve also, as it emerges from the infra-orbital foramen through an incision in the face, the whole trunk is set free, and can be removed by traction, all the dental branches being torn across. The displaced structures are then put back in position, the zygoma is sutured with silver wire, and the incision in the skin closed. The results gained by this method have been very satisfactory.

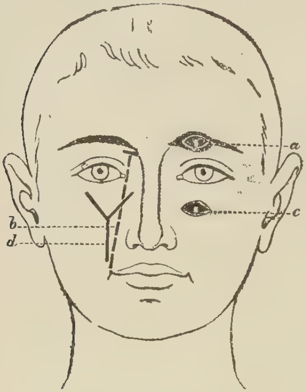

FIG. 126.

a, Incision for division of supra-orbital nerve; *b*, line indicating position of supra-trochlear nerve, passing from angle of mouth through the inner canthus; the short cross-line at its upper end is the incision required to expose it; *c*, position of infra-orbital nerve and incision; *d*, Carnochan's incision for neurectomy of the second division.

It is probable that an *intracranial section of the root of the second division*, followed by filling the foramen rotundum from inside by rubber or a metal plug, will give equally good or better results with less risk and deformity. The Hartley-Krause plan of procedure for removal of the Gasserian ganglion is employed.

In the *third division* trigeminal tic usually affects the lingual and inferior dental branches, and should be dealt with at the foramen ovale by intracranial or extracranial section of the trunk.

The *Inferior Dental Nerve* is sometimes, however, the seat of neuralgia, due to compression in its bony canal as a result of dental troubles. It may then suffice to trephine the outer bony wall of the inferior maxilla, making the necessary incision along its lower border, and remove half its thickness, so as to expose the nerve in its canal.

Extracranial section of the third division at the foramen ovale is best accomplished by turning forward a flap of skin and subcutaneous tissue from the parotid region (Fig. 105, B), exposing thus the parotid gland with the socia parotidis and the masseter muscle. The masseter is then divided transversely immediately below the socia parotidis, and the vertical ramus of the inferior maxilla cleared of muscle and periosteum, so as to allow the application of a $\frac{3}{4}$-inch trephine just below the sigmoid notch, the remaining bridge of bone being subsequently removed by cutting pliers. The lingual and dental nerves are usually found close together, emerging from under the outer pterygoid muscle, and lying between the internal pterygoid and the mandible. By retracting the external pterygoid outwards, the foramen ovale can usually be seen, if electric illumination is employed, and the nerve-trunks divided at the point of exit. A good deal of bleeding often occurs from the internal maxillary vessels and their branches. The wound usually heals well, and leaves but little scar, although some impairment in the mobility of the jaw may result from the cicatrization following disturbance of the muscles and tissues.

Removal of the Gasserian ganglion is now usually undertaken through the temporal region by some modification of what is known as the Hartley-Krause method. The pterygoid route* originally followed in the pioneer operations by the late Mr. William Rose must be acknowledged to give insufficient exposure to ensure satisfactory removal of the ganglion, and has now been discarded.

The *Hartley-Krause operation* was devised independently by the two surgeons whose names are associated with it. An Ω-shaped flap is marked out in the temporal region, the base situated just above the zygoma. Through this the subjacent bone is removed, exposing the dura mater, which is gently stripped up from the middle fossa of the skull as far as the cavernous sinus. The middle meningeal artery is exposed and tied just above the foramen spinosum, or the foramen may be plugged with purified sponge or wax. Hæmorrhage from the small vessels, especially the veins, of the dura mater is sometimes profuse, but usually ceases upon gentle pressure. The dura mater and temporo-sphenoidal lobe of the brain are held up by suitably-shaped spatulæ, and the second and third divisions of the nerve are seen running from the ganglion to their foramina, where they are cut across. The dural sheath of the ganglion (cavum Meckelii) is opened, the ganglion itself detached from the bone, and as much of it as is thought necessary removed. The cavernous sinus may be wounded in this stage, or the dura itself give way and cerebro-spinal fluid escape. Removal of the spatulæ allows the brain to re-expand, and the wound can then be closed.

Special care must be taken of the eye, as its nutrition is likely to suffer. The conjunctival sac should be washed out before operation with warm sublimate solution (1 in 2,000), and the lids stitched together. These stitches are removed on the fourth or fifth day, and the conjunctiva washed with warm boracic lotion, but a pad should be kept over the eye for at least a fortnight.

The **Sixth Nerve** may be torn or compressed, either in its intracranial course along the inner wall of the cavernous sinus, or as it passes through the sphenoidal fissure, or in the orbit, as a result of penetrating wounds or blows. Its division causes paralysis of the external rectus and consequent internal strabismus.

The **Seventh or Facial Nerve** may be *paralyzed* from a great variety of causes, which may be described under the following headings:

(*a*) *Intracranial Lesions.*—If simply *cortical*, as from pressure, hæmorrhage, degeneration, etc., a limited portion of the opposite side of the face is usually involved. If *subcortical*, or in the corona radiata or corpus striatum, as from hæmorrhage, or softening due to carotid thrombosis or embolus, the paralysis appears on the opposite side together with hemiplegia, but only the lower half of the face is affected, the associated movements of the eyelids being left. If the lesion is situated in the *pons*, the deep facial centres may be implicated, and then paralysis with rapid atrophy of the facial muscles ensues on the same side as the lesion, together with loss of power of the opposite arm and leg (crossed paralysis). If the *root* of the nerve between the centres and the internal auditory meatus is involved, the whole of the same side of the face is paralyzed, accompanied, as a rule, by deafness.

(*b*) *Cranial Lesions.*—There are two not uncommon causes grouped under this heading, viz., (i.) fracture of the base of the skull, involving the petrous bone, the paralysis supervening either immediately after the injury from laceration, a rare phenomenon, or some weeks later from implication in organizing blood-clot or callus, the usual cause; or (ii.) as a complication of chronic otorrhœa, due to compression or inflammation of the nerve in the aqueductus Fallopii. In both these forms the palsy is complete on the side affected, and owing to the communication of the facial with the petrosal nerves in this part of its course, there may be unilateral drooping of the velum palati, the uvula being deflected towards the sound side.

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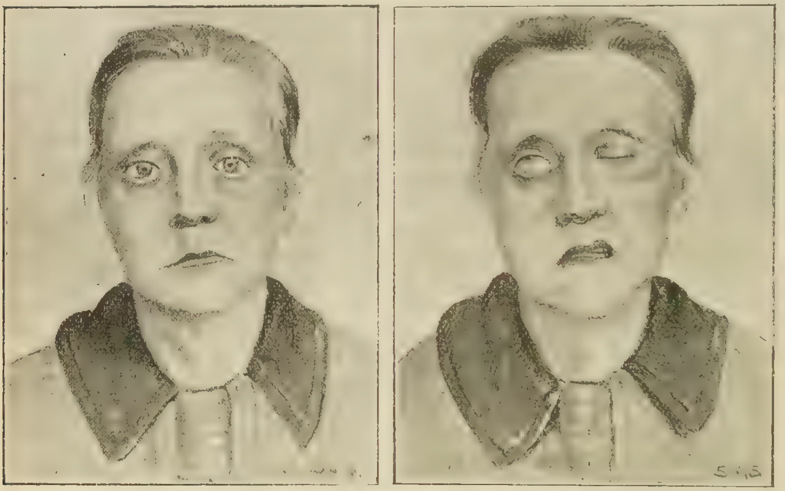
* For a description of this operation, see Rose, 'On the Surgical Treatment of Trigeminal Neuralgia' (Lettsomian Lectures, 1892): Baillière, Tindall and Cox; and J. Hutchinson, 'The Surgical Treatment of Facial Neuralgia': Bale, Sons and Danielsson, Limited.

(*c*) *Extracranial lesions* from injury, inflammation from exposure to cold, or the pressure of a tumour, *e.g.*, malignant disease of the parotid. This variety has been called 'Bell's palsy,' and is usually characterized by the whole side of the face being affected, but without implication of the palate or uvula.



FIGS. 127 AND 128.—RIGHT-SIDED FACIAL PARALYSIS.

On the left hand the face is in a position of rest; on the right hand an attempt has been made to close the eyes, that on the paralyzed side remaining open, and the eyeball rolling upwards and outwards, whilst the asymmetry of the face becomes more manifest.

The general **Signs** of facial paralysis (Fig. 127) are as follows: The side of the face is immobile and expressionless, all the natural folds and wrinkles being lost; the eye cannot be completely closed, and on attempting to do so (Fig. 128) the eyeball is usually seen to roll upwards and outwards; ulceration, and even perforation, of the cornea may result from this exposure. From the drooping and relaxation of the lower eyelid, the apposition of the punctum lachrymale to the conjunctiva is imperfect, and thus tears escape over the face (epiphora), a condition aggravated by the loss of the suction-like action of the lachrymal sac, owing to the associated paralysis of the tendo oculi and tensor tarsi. On attempting to move the face, as in laughing or showing the teeth, the muscles on the non-paralyzed side are alone contracted, and marked asymmetry results from the drawing over of the opposite side. The lips cannot be closed firmly, and hence whistling and such-like actions are prevented. Food collects between the cheek and the teeth, owing to paralysis of the buccinator, and the patient after a meal has to clear out the débris with a spoon or his fingers.

The **Treatment** of facial paralysis must, if possible, be directed to its cause. Accidental division of its extracranial portion must be followed by suture, either immediate or secondary. When due to the pressure of a tumour, it may be possible to free it by operation. In cases caused by cold, medical treatment, including massage and electricity, must be relied on, and will usually prove effective. When the paralysis persists, and especially if due to some cranial lesion which cannot be reached, **nerve-anastomosis** may be undertaken, the whole or a portion of the spinal accessory or hypoglossal nerve being united to the divided peripheral end of the facial nerve. The results hitherto obtained in a few cases have been encouraging; facial movements slowly return, but are first elicited by and accompanied with movement of the shoulder or tongue; in time, however, they become more independent, but are rarely quite free. However, the operation gives a certain amount of muscular power, and may remove the facial asymmetry so characteristic of this lesion.

Facial Tic (or histrionic spasm) consists of a clonic contraction of the facial muscles, due to some central lesion in the pons or cortex, or the reflex result of an irritative lesion of the nasal mucous membrane or of the teeth. The condition causes great discomfort to the patient, and may involve the whole side of the face, or merely one part of it, such as the orbicularis oculi. **Treatment** consists in the administration of nerve tonics or antispasmodics, in the removal of sources of reflex irritation, and, failing that, in *stretching*, or even in severe cases dividing, the *facial nerve*.

Operation.—The facial nerve is exposed immediately below the ear, its position being indicated by a horizontal line drawn from the middle of the anterior border of the mastoid process, and usually corresponding to the point where the mastoid meets the lobule of the ear. The incision extends from just behind the external meatus along the anterior border of the sterno-mastoid muscle to the level of the angle of the jaw. The parotid gland is separated from the muscle, and both are well retracted, exposing by this means the posterior belly of the digastric. The facial nerve is found above this, running directly forwards from the centre of the mastoid process. The great auricular nerve is divided in the superficial incision, and the posterior auricular vessels will require a ligature. The internal jugular vein is close to the posterior margin of the wound. The operation is a deep one, and by no means easy in a patient with a thick neck. The *effect* of stretching the nerve is to paralyze it temporarily, but the ultimate results have been by no means encouraging, only one case out of twenty collected by Godlee being successful.

The **Auditory Nerve** may be injured in fractures of the base of the skull, either one or both sides being involved. Incurable deafness usually results, often associated with facial palsy.

It is a little doubtful what effect would be produced by injury of the **Glosso-pharyngeal Nerve,** but in one case in which it was supposed to be compressed the patient suffered from difficulty in swallowing and speaking, together with persistent ulceration of the tongue; death resulted from œdema of the glottis.

A severe crushing injury to the **Pneumogastric Nerve** may prove rapidly fatal from heart failure or pulmonary congestion, but less serious lesions result in palpitation, vomiting, and a sense of suffocation; such phenomena sometimes manifest themselves after head injuries, especially fractures involving the posterior fossa, and indicate that the jugular foramen has been encroached on. The nerve is also exposed to injury in operations about the neck, *e.g.*, ligature of the carotid, or removal of tuberculous or malignant glands. Irritation causes vomiting, coughing, or perhaps a temporary inhibition of the heart's action; one-sided division sometimes does comparatively little immediate harm, but if both nerves are divided, death results from laryngeal paralysis or from such complications as œdema or congestion of the lungs.

The effect on the larynx of these lesions is described elsewhere (p. 906), but one may note here that in the *early* stages compression-paralysis of the recurrent laryngeal nerve, as by an aneurism, affects the abductor muscle (crico-arytenoideus posticus), the result being that the cord involved is approximated to the middle line, and then the voice is not impaired, although dyspnœa is present. At a *later* stage compression-paralysis corresponds to the phenomena produced by complete section of the nerve, as in an operation for goitre, viz., the cord lies in the cadaveric position, *i.e.*, half-way between its position in phonation and deep inspiration; in this, breathing is unimpaired, but the voice is husky.

The **Spinal Accessory Nerve** may be irritated, either at its exit from the skull by a fracture running through the jugular foramen, or in its peripheral course by inflamed lymphatic glands, etc. It is occasionally divided in operations for the removal of tuberculous or malignant glands, and in children this may cause serious deformity from drooping of the shoulder, especially if the branches of the cervical plexus supplying the trapezius are also severed. Clonic spasm of the sterno-mastoid and trapezius is generally due to central changes, and it is for this form of spasmodic torticollis that *stretching or division of the spinal accessory nerve* is employed.

Operation.—The nerve runs downwards and backwards at right angles to the centre of a line passing from the angle of the jaw to the apex of the mastoid process; it enters the deep aspect of the sterno-mastoid about 3 inches below that spot. An incision is made along the anterior border of the sterno-mastoid, reaching from the ear to the cornu of the hyoid bone. The fascia is divided, and the muscle drawn backwards to expose the posterior belly of the digastric, from under the lower border of which the nerve emerges, passing first in front.

and then below the transverse process of the atlas, which can be readily felt. The operation has not given good results, since, even if the twitching of the head and neck ceases, the spasmodic phenomena often recur elsewhere.

The **Hypoglossal Nerve** may be accidentally divided in an operation, or compressed by an aneurism of the external carotid, or by a new growth. Unilateral paralysis or weakness of the tongue results, the organ, when protruded, being directed towards the paralyzed side.

The Spinal Nerves.

The nerves constituting the **Cervical Plexus** are exposed to injury either from blows, dislocations of the cervical spine, penetrating wounds, or during operations. No very serious results follow, except in the case of the **Phrenic Nerve,** division of which may cause instant death by paralysis of the diaphragm, although when but one nerve is divided the patient can survive. Irritation of the nerve gives rise to spasmodic cough or hiccough.

The **Brachial Plexus** may occasionally be divided by *cuts or stabs* in the lower part of the posterior triangle, and the accident will be characterized by the motor or sensory phenomena corresponding to the particular nerves involved; obviously the upper nerves of the plexus are most exposed to this form of injury. Treatment consists in laying the parts open by a suitable incision, finding the divided ends, and performing primary nerve suture.

Tears or contusions of the plexus, a more common accident, may be complete or partial, and result from injuries in which the arm is dragged suddenly upwards, as when in falling a person clutches at some projecting body, or from forcible depression of the shoulder in a fall whilst the head is driven towards the opposite side, the nerve-roots being thereby wrenched from their attachments, or the nerve-trunks compressed by the clavicle against the first rib. Long-continued hyper-extension and abduction of the arm, as during an operation in the Trendelenburg position, also cause undue traction of the roots of the plexus, especially of the fifth and sixth nerves. A fracture of the clavicle by direct violence may result in injury of the plexus, as also the pressure of a cervical rib. Dislocation of the head of the humerus into the axilla, or the attempts to reduce it, may also be responsible for injuries, especially to the inner cord. The lesions consist either of a complete rupture of the nerve-trunks, or of a partial rupture with hæmorrhage into and around the sheaths. If the sheaths remain untorn, repair is usually established after a time; but where a complete laceration has occurred, much cicatricial tissue is likely to form, and unless operation is undertaken, repair is improbable.

Symptoms.—Sometimes the whole arm is paralyzed, and lies flaccid and anæsthetic by the patient's side. Sensation is alone present down the inner side of the arm as far as the elbow (intercosto-humeral nerve), and for a more limited portion on the outer side. Paralysis often involves the pectoralis and scapular muscles, but the rhomboids and serratus magnus retain their nerve-supply.

More frequently the manifestations correspond to that seen in the *brachial birth palsy*, due to the forcible stretching and tearing of the root of the fifth cervical nerve, and sometimes in part of the sixth. It is caused by overstretching of the head during delivery, and may occur equally in vertex or breech presentations; but is usually unilateral, and affects more frequently the left arm. The result in this, as is traumatic cases, is the appearance of what is known as the *Erb-Duchenne* paralysis, *i.e.*, loss of power of the deltoid, biceps, spinati, brachialis anticus, and supinators, together with anæsthesia or paræsthesia in the region supplied by the fifth root. The arm is adducted and rotated in at the shoulder, and the fore-arm is extended and pronated. The lesion in infants is not likely to be noted at birth, but becomes apparent in a few weeks.

If the injury is limited to the inner cord of the plexus, the symptoms produced are chiefly localized in the hand where the intrinsic muscles, both of the median and ulnar groups, are paralyzed, together with loss of sensation along the inner side of the arm and fore-arm.

Occasionally the effect is more limited, as when a blow on the back of the neck leads to paralysis of the serratus magnus and rhomboids, and to the subsequent development of a 'winged scapula.'

Treatment necessarily varies with the situation and probable degree of the injury. Obvious causes of pressure, such as the depressed fragments of a broken clavicle or the callus derived therefrom, must be removed. A diagnosis of complete rupture of the nerves can only be made in most cases, however, after the development of the reaction of degeneration, and hence expectant measures must be adopted in the early stages. The arm is kept to the side, and fomentations applied to relieve the pain. After a while massage and electricity are employed, and it is most interesting in many cases to watch the gradual restoration of power and sensation to a paralyzed limb. The appearance of the reaction of degeneration indicates that the period of inactivity is over, and an attempt must be made by operation to restore the continuity of the nerves. They are exposed by a curved incision running parallel to the clavicle, and following up the posterior border of the sterno-mastoid. The scalenus anticus is defined, and the nerve-roots found emerging from between it and the scalenus medius; cicatricial tissue is removed; the ends of the nerves are freshened and sutured together. The results of such operations have been, on the whole, encouraging.

Neuritis and neuralgia of the brachial plexus occur, and are treated along the usual lines. Should the neuralgia persist and prove uncontrollable, or if clonic spasm of the muscles of the arm and shoulder develop, *stretching of the brachial plexus* may be required.

The **Circumflex Nerve** is liable to injury from its exposed position, winding round the outer side of the neck of the humerus about a finger's breadth above the middle of the deltoid. Blows upon the shoulder may in this way cause paralysis; it is sometimes torn or compressed in fractures of the surgical neck of the humerus, or in dislocation of the shoulder, or it may be impacted in the callus arising from the former injury. Paralysis of the deltoid and teres minor follows, evidenced by inability to raise the arm from the side, whilst the wasting of the former muscle causes undue prominence of the acromion. There may be temporary anæsthesia over the posterior fold of the axilla, but this does not last long. No operative treatment has been adopted, although there is no reason why it should not be attempted in suitable cases.

The **Musculo-spiral Nerve** is not unfrequently damaged in fractures and dislocations of the upper extremity of the humerus, but is chiefly exposed to injury in the musculo-spiral groove, where it lies close to the bone. It is implicated with or without other nerves in crutch palsy, or by lying asleep with the arm across the edge of a chair or table, as so frequently occurs in drunken people (' Saturday-night paralysis '). It is not unknown after operations when the outstretched arm has rested on the edge of the table, or when the Trendelenburg position has been adopted and the arms have been kept above the patient's head, the upper end of the humerus pressing against the brachial plexus. In this position the arms should not be raised to more than a right angle with the trunk, or may be folded across the chest. The resulting paralytic symptoms are not confined to the musculo-spiral nerve.

Total division of the nerve causes the following symptoms:

A. Anæsthesia. If the nerve is divided in the upper third of the arm—*i.e.*, above the origin of its external cutaneous branch—there is loss of both epicritic and protopathic sensation over the radial half of the dorsum of the hand, of the epicritic a little more than of the protopathic. Section of the radial nerve in the upper third of the fore-arm causes no loss of sensation, which is supplied to the back of the hand by the external cutaneous of the brachial plexus; but section in the lower third causes a limited loss of epicritic sense over the back of the thumb.

B. Paralysis of the following groups of muscles:

(i.) Of the extensor of the fore-arm (triceps); hence the fore-arm can only be extended by its own weight.

(ii.) Of the long and short supinators; hence the hand is pronated, the only supinator remaining being the biceps.

(iii.) Of the radial and ulnar extensors of the wrist; hence wrist-drop (Fig. 129), a condition also present in certain lesions of toxic or central origin, *e.g.*, lead palsy.

(iv.) Of the extensors of the fingers and thumb, which either hang limp and motionless, or may be bent up into the palm from the unopposed action of the flexor muscles. If, however, the wrist and proximal phalanges are supported and extended, the terminal phalanges can be straightened by the action of the interossei and lumbricales.

Treatment consists in massage and electricity applied to the muscles, whilst fixation of the deformity and secondary changes in the length of the muscles are prevented by the application of a palmar splint. The absence of improvement, together with the appearance of the reaction of degeneration, indicates that the nerve has been torn across, and indicates the necessity for operative treatment. The nerve is laid bare at the site of injury, scar tissue removed, and the ends approximated and sutured, if possible. Should this be impossible, nerve-grafting may be attempted.

Operation.—The musculo-spiral nerve can be exposed on the outer side of the arm after it has traversed the external intermuscular septum, where it lies between the brachialis anticus and supinator longus. To define this intersection the fore-arm is semi-flexed and pronated, and an incision made extending from the centre of the crease of the elbow upwards and outwards along a line made by prolonging upwards the radial border of the fore-arm, which in this position corresponds with the supinator longus muscle. The interspace is opened up, and the nerve found together with the termination of the superior profunda artery. From this point the nerve may be traced upwards, if necessary, by dividing the intermuscular septum, and retracting or dividing the triceps.

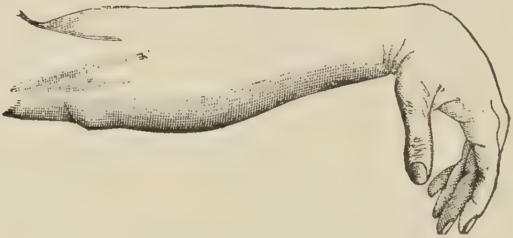


FIG. 129.—WRIST-DROP FROM PARALYSIS OF THE MUSCULO-SPIRAL NERVE. (TILLMANNS.)

To expose the upper part of the nerve as it enters the groove, the arm is placed over the body, and the posterior border of the deltoid defined. An oblique incision is made a finger's breadth behind this, and the intersection between the long and outer heads of the triceps found. By opening up this space the finger can be passed down to the bone, and the nerve, together with the superior profunda artery, readily exposed.

Where the nerve is impacted in the callus arising from a fracture of the middle of the shaft of the humerus, it is often best to expose it by a median incision down the back of the arm, splitting the triceps, the centre of the wound being opposite the insertion of the deltoid.

The **Median Nerve** may be damaged in fractures and dislocations of the humerus, but is most frequently injured just above the wrist by glass wounds, due either to bursting of bottles, etc., or to thrusting the hand and arm through a window. *Paralysis* necessarily results in these cases, with the following symptoms:

If divided just above the wrist:

A. Anæsthesia. Loss of epicritic sensation over the palmar aspect of the radial side of the hand, over the front of the thumb, index, middle, and half the ring fingers, and over varying portions of the dorsum of the same (Fig. 130); loss of protopathic sensation including analgesia to pinpricks over a much more limited portion, varying considerably in different cases with the area of distribution of the terminal branches of the external cutaneous and ulnar nerves.

B. (i.) Paralysis of the outer group of the short muscles of the thumb (*i.e.*, abductor, opponens, and outer half of the flexor brevis pollicis), so that the thenar eminence wastes, and the movement of 'opposition' is impaired, the thumb remaining extended by the side of the fingers (Duchenne's 'ape-hand').

(ii.) Paralysis of the outer two lumbrical muscles, causing loss of power of flexion at the metacarpophalangeal joints of the index and middle fingers.

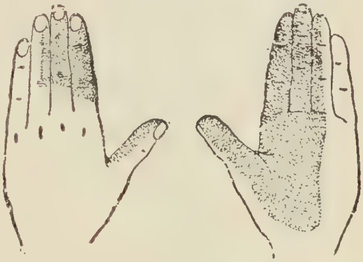


FIG. 130. — DIVISION OF MEDIAN NERVE ABOVE THE WRIST. (AFTER SHERREN.)

The shaded parts indicate the area over which epicritic sensation is lost.

The great impairment of mobility in the hand and fingers so often seen in these cases depends not so much on paralysis of muscles as on the fact that in the majority of them the synovial sheaths of the wrist are also laid open and involved in septic inflammation, which leads to the formation of diffuse adhesions. Hence the progress is often unsatisfactory, even when the nerve has been skilfully sutured.

If divided at the bend of the elbow or in the arm, to the above-described symptoms are added:

(i.) Loss of pronation from paralysis of the two pronators.

(ii.) Paralysis of the flexor carpi radialis, causing defective wrist flexion on the radial side and impaired radial abduction.

(iii.) Paralysis of the flexor longus pollicis, of the flexor sublimis, and the outer half of the flexor profundus digitorum, leading to loss of power in the hand-grasp, especially on the radial side, and perhaps hyper-extension of the wrist.

(iv.) Paralysis of the palmaris longus.

The **Ulnar Nerve** is exposed to injury at the wrist, as also in the hollow between the olecranon and the inner condyle of the humerus, and paralysis may be caused by wounds, fractures, blows, implication in callus, etc. The symptoms are very characteristic.

If divided at the elbow :

A. Analgesia or loss of protopathic sensation of the little finger and ulnar border of the palm, back and front, seldom of the ring finger; anæsthesia to light touch (loss of epicritic sensation) of the ulnar side of the front of the wrist and palm, of the back of the hand, and of the little and half the ring fingers, back and front (Fig. 131).

B. (i.) Paralysis of the flexor carpi ulnaris, causing weakness in flexion and in ulnar adduction of the wrist.

(ii.) Paralysis of the inner half of the flexor profundus, with weakened hand-grasp, especially in the ring and little fingers.

(iii.) Paralysis of the two inner lumbricales and of all the interossei; hence, loss of adduction and abduction of the fingers, with flexion of the two last phalanges in each finger and hyper-extension at the metacarpo-phalangeal joint (*main-en-griffe*) or claw-hand (Fig. 133). The interosseous spaces also become very evident from atrophy of these muscles.

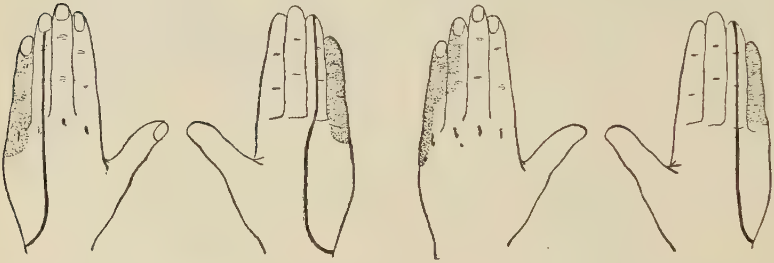


FIG. 131. FIG. 132.

ANÆSTHESIA RESULTING FROM DIVISION OF ULNAR NERVE. (AFTER SHERREN.)

In Fig. 131 the nerve was divided above the origin of the dorsal branch; in Fig. 132 below that branch close to the wrist. The continuous dark line indicates the limits of the loss of epicritic sensation; the shaded area shows the loss of protopathic sensation.

(iv.) Paralysis of the short muscles of the little finger, of the inner group of short thumb muscles (adductor transversus, adductor obliquus, and deep portion of flexor brevis), and of the palmaris brevis.

If divided just above the wrist, the anæsthesia only involves the palmar aspect of the hand and back of the terminal phalanges (Fig. 132), whilst the paralysis merely affects the short palmar muscles. Additional impairment of movement may, however, arise from septic inflammation of the long tendons and their sheaths.

Treatment.—If divided, the nerve must be dealt with (according to the rules already given) at the injured spot.

The **Intercostal Nerves** are frequently the seat of severe neuralgia, either from a chronic neuritis, probably of toxic origin, from compression by tumours or inflammatory lesions of the ribs, or from injury or pressure directed to the nerve-roots as they emerge from the spine, as in spinal caries (girdle-pain). Herpes zoster or shingles is sometimes associated with such pain, and may be followed by some amount of anæsthesia.

The **Twelfth Dorsal Nerve** is not unfrequently the seat of neuralgia of a somewhat severe type, following its distribution to the anterior abdominal wall and buttock, and occasionally leading to a mistaken diagnosis of some abdominal lesion, *e.g.*, appendicitis or chronic ovaritis, and not a few operations have been unnecessarily undertaken in consequence. In some cases it is caused by the undue projection of the tip of the last rib, which becomes injured and inflamed, the nerve becoming adherent thereto; removal of the rib or its tip suffices to cure the patient. In not a few cases of operations on the kidney the nerve becomes entangled in the scar, and this is a source of most troublesome pain, the only cure of which is to cut down, free the nerve, and pull out its central end.

Sciatica, or neuralgia of the great sciatic nerve, is a most painful affection, and often exceedingly intractable. It may arise from the following **Causes**: (*a*) Inflammation of the neurilemma (acute or chronic), the result of cold, injury, gout, rheumatism, syphilis, and many toxic agents; (*b*) pressure upon the extrapelvic portion of the nerve, as by aneurisms, tumours, or old-standing dislocations of the head of the femur on the dorsum ilii; (*c*) similar pressure upon the nerve in the pelvis, or as it emerges through the sacro-sciatic notch, as from sarcoma or osteoma of the pelvic bones, rectal or uterine cancer, a pregnant uterus, or uterine fibroids; (*d*) pressure upon the nerve-roots in the spinal canal, as from caries or sarcoma; (*e*) chronic diseases of the spinal cord, such as tabes.

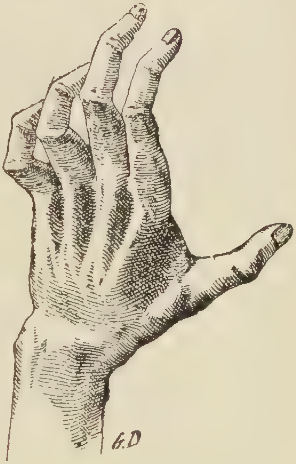


FIG. 133.—CLAW-HAND (MAIN-EN-GRIFFE) FROM ULNAR PARALYSIS. (AFTER BYROM BRAMWELL.)

The **Symptoms** are very characteristic, the pain shooting down the back of the thigh and being often referred to the toes. It is of a paroxysmal nature, and may be brought on by pressure over almost any part of the nerve or by movements of the thigh, and hence the patient's gait is stiff and shambling. Tenderness in the line of the nerve is felt when the cause is a peripheral neuritis, and the trunk may sometimes be detected on palpation as a thickened cord. The limb is usually kept slightly bent, but complete flexion of the thigh on the pelvis is an impossibility; and if, when the patient is standing against a wall, the limb can be raised to a right angle with the knee extended, it is certain that sciatica is not present. Careful examination of the patient's pelvis must be made before determining that a case is 'merely sciatica,' especially if the pain has lasted any time.

The **Treatment** necessarily varies with the cause. If due to neuritis or perineuritis, general anti-syphilitic or anti-rheumatic measures may be adopted, and blisters or sedative remedies in the more acute cases applied to the back of the thigh. Hypodermic injections of morphia and atropine may also be useful; but if all the usual anti-neuralgic remedies have been exhausted without benefit, *stretching of the nerve* may be employed. This may be accomplished without operation by flexing the thigh upon the abdomen and then extending the knee; in cases of sciatica an anæsthetic will be required for this, but it may be attempted before undertaking operative procedures.

The nerve is best *exposed* for stretching at the point where it emerges from under cover of the gluteus maximus, midway between the tuber ischii and the great trochanter. The patient lies in the prone position with the limb slightly flexed, and a 4 or 5 inch incision is made vertically downwards from the gluteal fold in the middle line of the thigh. The lower border of the gluteus maximus is first exposed, and its fibres are seen running downwards and outwards. The hamstring muscles emerging from under it are drawn inwards, and the nerve is found ensheathed in loose connective tissue; it is stretched, by a finger hooked under it, both peripherally and proximally.

The **External Popliteal Nerve** may be divided during a subcutaneous tenotomy of the biceps, to which it lies immediately internal; or compressed, as it winds round the neck of the fibula, by strapping, bandages, or splints; or it may be injured in fractures of the neck of the fibula. Total division causes anæsthesia of the dorsum of the foot, and of a varying portion of the front and outer side of the leg, together with paralysis of the extensor and peroneal groups of muscles. In the earlier stages inability to dorsi-flex the foot results in a condition of ‘ drop-foot,’ but later on the contraction of the unbalanced opposing groups results in the paralytic form of talipes equino-varus. The nerve may be exposed by making an incision 1½ inches long to the inner side of the biceps tendon, terminating at the neck of the fibula. The knee is then flexed, and the nerve is readily found embedded in the loose cellular tissue of the popliteal space.

The **Internal Popliteal Nerve** is much less exposed to injury owing to its more sheltered position. Division results in loss of epicritic and protopathic sensation over the sole of the foot, and of epicritic sensation for the plantar surface of all the toes and for the dorsal aspect of the outer four; also in paralysis of the calf muscles, flexors of the foot and toes, and of the short muscles of the sole. Paralytic talipes calcaneo-valgus is very likely to ensue. The nerve is laid bare by a vertical incision in the middle of the popliteal space, which should avoid the short saphena vein. After division of the deep fascia, the nerve is the most superficial structure.

If the **Tibial Nerves** are divided, the resulting effects are more limited; thus, paralysis of the extensors of the foot and paralytic talipes equinus result from division of the anterior tibial; and paralysis of the short and long flexors of the foot and of the interossei, with resulting talipes calcaneo-valgus, follow lesions of the posterior tibial. The nerves may be exposed in the same way as the accompanying arteries (p. 339).

The **Sympathetic Nerve-trunk** in the neck is occasionally compressed by aneurisms or tumours. If merely irritated, dilatation of the pupil on the same side and unilateral sweating of the head and face are produced; but, if divided, the pupil is contracted from unbalanced action of the third nerve. It has also been completely excised on both sides in the treatment of Graves' disease and for glaucoma, and the operation appears to be of some value.

The Nerve-Roots.

It is a well-known fact that during the development of the embryo the primitive spinal cord, which was originally co-terminous with the trunk and with the vertebral column, gradually lags behind in its growth, so that at birth and subsequently it does not extend down the canal further than the lower border of the first lumbar vertebra. This necessarily involves a displacement of the attachment of the spinal nerves upwards, so that these points of origin of the nerves do not correspond to the inter-vertebral foramina, and a variable length of the nerve exists within the canal formed at first by the junction of the anterior or motor ramus with the ganglionated posterior or sensory ramus. In the cervical region each spinal segment is about one vertebra above its corresponding body; in the upper dorsal region this interval amounts nearly to two vertebræ; whilst all the spinal segments corresponding to the lumbar, sacral, and coccygeal nerves are crowded between the tenth dorsal and the first lumbar vertebræ.

The nerve-roots after this downward intraspinal course pass through the intervertebral foramina, where they are exposed to injury and pressure, and after various divisions and combinations constitute the peripheral nerves. It must be remembered that almost all the peripheral nerve-trunks are derived from a number of nerve-roots, and the complex distribution of these has been carefully worked out. It follows that the distribution of sensation over the trunk according to the nerve-roots is a very different thing to that of the peripheral nerves, and the practitioner and student must carefully study the diagrams appended (Figs. 134 and 135) in order to familiarize themselves with this arrangement. Particularly noticeable is the amount of overlapping of sensory areas, a provision whereby defective sensation due to localized injuries may be minimized. Sherrington has shown that in apes cutaneous anæsthesia will not result from the division of any two consecutive posterior nerve-roots, but only when three are divided; this has been confirmed in man. The control of muscles or groups of muscles is similarly distributed over two or three consecutive nerve-roots, presumably with a similar object; whilst the nerve-fibres from muscles, tendons, ligaments, etc., upon which the muscular tone and control of the limbs so much depends, also enter the cord by several nerve-roots.

Pressure on the nerve-roots may be caused by tumours of the spine or spinal cord, by tuberculous or gummatous lesions, or by callus or

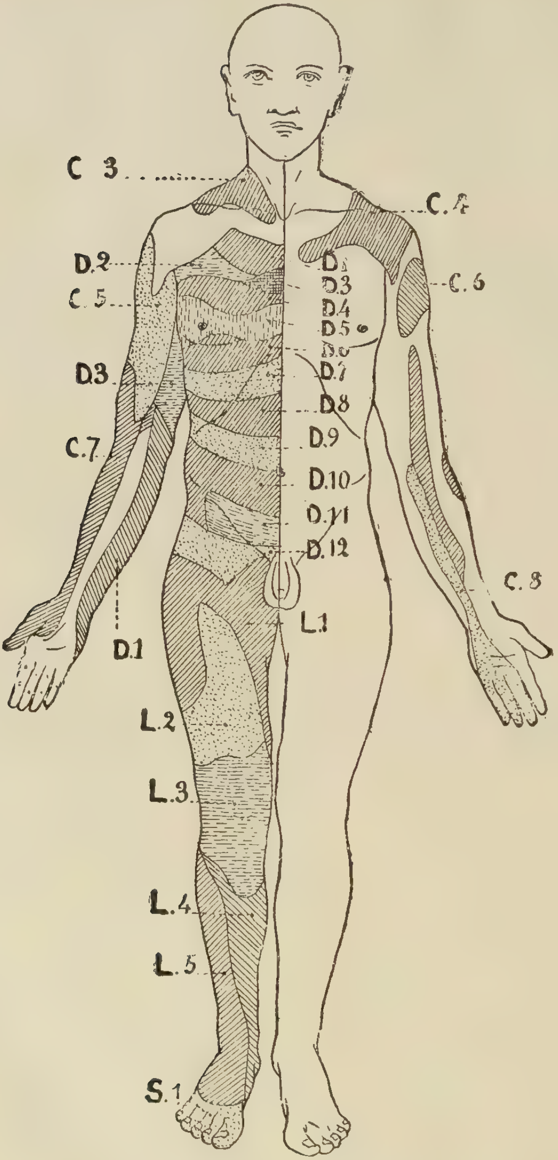


FIG. 134.—NERVE-ROOT AREAS: ANTERIOR ASPECT OF TRUNK. (AFTER HEAD AND OSLER.)

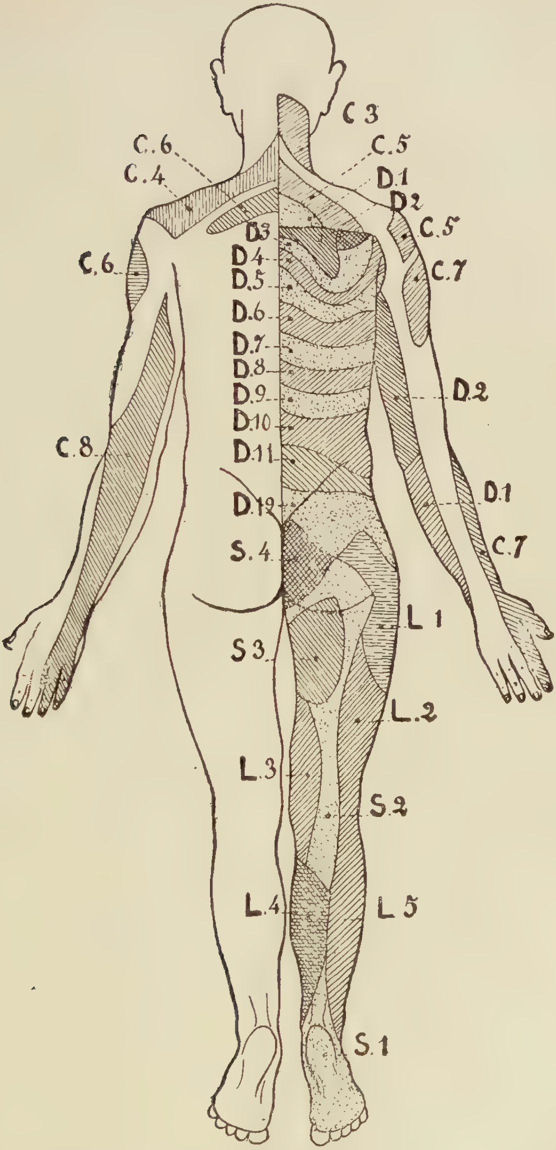


FIG. 135.—NERVE-ROOT AREAS: POSTERIOR ASPECT. (AFTER HEAD AND OSLER.)

adhesions forming about the intervertebral foramina. Intense neuralgia is the most prominent symptom, together with hyperæsthesia; this, it will be noted, always follows the nerve-root areas, and not those of the peripheral nerves. Herpes zoster may be induced by the affection, and in time anæsthesia may follow.

Division of the Posterior Roots (Förster's operation) has now been undertaken for a variety of conditions, and may be looked on as justifiable in suitable cases, such as—(1) Intractable neuralgia, due either to irremovable pressure or to an ascending neuritis, where medical methods are of no avail. (2) To relieve persistent visceral crises and the lightning pains of tabes dorsalis. The crises are supposed to be due to the irritation in these organs of sensory sympathetic fibres, which enter the cord in the posterior nerve-roots. (3) The relief of certain spastic deformities, more particularly of the legs, has been, perhaps, the most successful result of this operation. This proceeding is based on the presumption that interference with the upper motor pyramidal track (*i.e.*, between the cortex and the spinal centres) not only impairs the passage of excito-motor impulses, but also hampers the conduction of inhibitory impulses from cortex to spinal centre. The result of this is that peripheral stimuli reaching the centres from below have an undue power of producing reflex activity, and hence, in such conditions as the cerebral diplegia of children, spastic contraction of muscles is induced, and the mere placing of the foot on the ground in the attempt to walk produces such spastic contortions as to render progress impossible. The distribution of afferent stimuli through at least three nerve-roots renders it possible to divide suitably selected nerve-roots in order to minimize this spastic condition without producing anæsthesia or ataxia, providing that not more than two consecutive posterior nerve-roots are ever severed. The result of such a procedure is that the spasticity gradually diminishes, and after suitable freeing of contracted muscles (by massage, forcible movements, or even by tenotomy, myotomy, etc.) and educational exercises, walking becomes possible.

The **Operation** itself for a spastic condition of the legs is conducted usually in two stages. The first consists in removal of the laminæ of the whole of the lumbar vertebræ, and in opening the upper part of the sacral canal. A guiding stitch is introduced into the muscles opposite the tip of the fifth lumbar spine to act as a landmark to assist in the identification of the nerve-roots. The first sacral roots leave the dural canal at this level. The removal of the laminæ must be wide, and should include the internal articular processes, so as to allow of a clear recognition of the deeper parts. After a suitable interval the wound is reopened, and the spinal membranes incised; it is desirable to do this without hæmorrhage, thereby rendering identification of the nerve-roots more satisfactory. In most cases of cerebral diplegia or spastic paraplegia it suffices to divide the posterior nerve-roots of the second, third, and fifth lumbar nerves, and that of the second sacral.

CHAPTER XVII.

SURGICAL DISEASES OF THE SKIN AND OF THE CUTANEOUS APPENDAGES.

A **Boil** or **Furuncle** is a localized inflammation of the skin, usually terminating in suppuration, due to infection with staphylococci of a hair follicle or sebaceous gland. Experimentally, a plentiful crop of boils can be produced by rubbing a culture of staphylococci into the skin, and clinically there is little doubt that a similar infection is the most common cause of this condition. The secondary or satellite boils which form around a primary one are due to the friction upon the healthy integument of dressings, covered with pus and microbes.

People with coarse skins and a tendency to comedones are specially liable to the occurrence of boils, but some depressing constitutional condition, such as chronic Bright's disease or diabetes, is often present in patients who suffer from recurrent crops of boils. A gangrenous inflammation ensues after infection, resulting in the death of the hair follicle, or of the sweat or sebaceous gland involved, and of the surrounding connective tissue, and the slough thus formed is cast off by a process of suppuration. A matured or ripe boil, therefore, consists of a central slough or core, a zone of pus around it, and external to this granulation tissue merging into healthy skin and connective tissue.

Signs.—A boil commences as a small red irritable pimple, from which a hair may often be seen to protrude; it increases gradually in size, becoming more and more painful, until it forms a conical tumour, deep red in colour and exquisitely tender. A small whitish spot appears in the centre, and around this so-called core yellow pus can be seen. Finally it bursts, discharging the pus, and subsequently the core or slough comes away. The process is then at an end, and the wound rapidly heals by granulation. Occasionally the inflammation extends more deeply into the subcutaneous tissues, constituting a ' carbuncular boil.' Lymphangitis sometimes follows, and the neighbouring lymphatic glands may become sympathetically enlarged and painful, but rarely suppurate. A boil sometimes subsides without suppuration, leaving the parts thickened and infiltrated, the condition then being known as a ' blind boil.'

Treatment.—Many boils may be left to burst naturally, though possibly the process may be checked by painting them twice daily with iodine (2 per cent.) and applying Klapp's suction-glass two or three times a day. Where pus has formed, an incision is made, and the suction-ball persisted in till the slough has come away. In the later stages the skin around should be thoroughly purified, and the pus and core received on portions of wool soaked in carbolic lotion (1 in 20), and the cavity lightly swabbed out with pure carbolic acid. A small collodion dressing is then applied. Tonics, such as iron and quinine, are usually required, except in plethoric individuals, in whom a spare diet and abstinence from stimulants may be recommended. A change of air to a bracing seaside place is often advisable, especially when a succession of boils has appeared. In the more persistent cases a staphylococcal vaccine may be employed with advantage, and the boils will probably be quickly cured or aborted (p. 26).

A **Carbuncle** is a more extensive infective gangrene of the subcutaneous tissues, due to a local invasion with pyogenic microbes, the commonest being the *Staphylococcus pyogenes aureus*. It occurs in individuals run down by any general debilitating condition, such as albuminuria or diabetes, in whom the germicidal powers of the tissues are much depreciated; it is also occasionally met with as a sequela of acute fevers. The exciting cause may be some blow or squeeze, resulting in extravasation of blood or some local diminution of vitality; into this area cocci are implanted either by auto-infection, or more usually through the sweat-glands or hair follicles, or through some slight superficial abrasion.

Signs.—A carbuncle commences as a hard, painful infiltration of the subcutaneous tissues, the skin over which becomes red and dusky. The swelling gradually increases in size in all directions, until a diameter of many inches may be reached. As it extends peripherally, the central parts, which were formerly brawny, become soft and boggy, and the overlying skin shows evidences of yielding to the pressure within. Vesicles form on the surface, and finally pustules; these in turn burst, and allow a tardy exit to the ashy-gray sloughs and purulent discharge accumulated below. Fresh openings gradually develop, leading to a cribriform condition of the cutis; some of these apertures enlarge and run into one another, producing a central irregular crateriform opening, at the bottom of which lies the necrotic tissue. As the violence of the inflammation subsides, the sloughs gradually separate, leaving a clean granulating wound. Carbuncles most frequently occur on the back, the nape of the neck, the shoulders, and nates, where the vitality of the tissues is never very active; when they form on more vascular parts, such as the face and lips, the consequences may be even more serious, since infective thrombosis of the large veins may follow, and this may quickly spread up to the cavernous sinus. The soft and spongy tissue of the cheek is a very favourable place for the extension of the necrotic process, and there may be a wide area of mischief under an apparently insignificant superficial lesion. A carbuncle is usually single, and may be accompanied by lymphangitis and a painful enlargement of the nearest lymphatic glands.

There is often considerable constitutional disturbance of an asthenic type, although the temperature is not necessarily much raised. A temporary glycosuria is sometimes present, and disappears as the condition improves, but occasionally the gravest symptoms of blood-poisoning (pyæmia or septicæmia) may supervene.

Treatment.—In the early stages Bier's treatment by induced hyperæmia may be successful in preventing suppuration, but where the organisms are at all virulent or the focus large, it will probably fail. In the later stages the most satisfactory treatment is to lay the carbuncle freely open under an anæsthetic, and scrape with a sharp spoon or cut away all sloughs until healthy tissue is reached, and then to disinfect the cavity thoroughly with pure carbolic acid or peroxide of hydrogen (10 volumes). The hollow thus formed is packed with gauze soaked in an iodoform emulsion (10 per cent.), and allowed to heal by granulation. Another less radical proceeding is to make a free crucial incision, and allow the sloughs to separate naturally, assisting matters by antiseptic fomentations or Klapp's suction-glass. Good food, iron, quinine, and alcohol according to judgment, must be administered, whilst appropriate medicine (*e.g.*, codeia or opium) and limitation of diet are necessary in diabetic patients.

A **Corn** (*clavus*) is a localized outgrowth of the epidermic layer of the skin, together with a central ingrowth of a hard, horny plug, which compresses and causes atrophy of the underlying papillæ, constituting a cup-shaped hollow, whilst the surrounding papillæ are hypertrophied. It is the presence of this central plug that constitutes the difference between a true corn and a simple callosity or diffuse overgrowth of the epidermis. Any abnormal pressure is capable of producing either condition, granting that it is not sufficiently severe or intense to lead to ulceration; but it is rare to find corns except on the feet, and the chief cause is badly-fitting boots. Two kinds of corns are described, viz., the hard and the soft.

The **hard corn** usually occurs on the little toe, or over the head of the metatarsal bone of the great toe, or over the heads of the first phalanges of the other toes, especially if there is any tendency to hammer-toe. They form more or less conical swellings, with a dark, dry, central plug, and are often very painful, especially when rain is threatening. Suppuration sometimes occurs beneath a corn, and the pain then becomes acute. If it is not attended to early, the pus may burrow and cause necrosis of deeper parts or a destructive arthritis. **Treatment** consists in paring the corn, after softening with hot water or treating with salicylic acid plaster (10 or 20 per cent.), or painting with a solution of salicylic acid in collodion.* A ring of felt plaster may subsequently be worn, but attention must be directed to the boots, and the cause of the trouble removed. Occasionally, where the toe is deformed, or disease of the bones or joints has developed, it is necessary to perform amputation.

A **soft corn** occurs between the toes, and owing to the absorption of sweat the surface looks white and sodden; it is often extremely painful. **Treatment** consists in removing the thickened cuticle after the use of salicylic acid. The parts are very carefully cleansed night and morning, and spirit of camphor painted on at night, whilst cotton-wool is worn between the toes during the day. Failing this, the corn must be removed by operation. The toes are held widely apart, and the incisions run transversely between them, so as to include the corn. The wound can be readily closed by sutures.

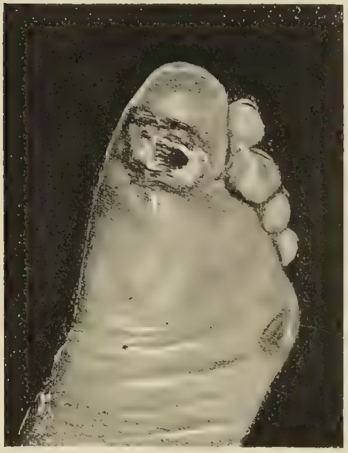


FIG. 136.—PERFORATING ULCER OF GREAT-TOE, PENETRATING TO BONES AND CAUSING NECROSIS.

The scar of an old healed ulcer of similar type is seen on the outer side of the foot.

Perforating Ulcer of the Foot forms on some part of the sole and progresses deeply so as to involve sooner or later the bones and joints. It is usually due to two main factors, viz., *anæsthesia* of the sole, and more or less persistent *traumatism*, such as arises from wearing a tight boot or from the presence of a nail, which is not noticed owing to the concurrent anæsthesia. It is therefore likely to be met with: (1) In certain central nervous diseases—*e.g.*, tabes dorsalis, syringomyelia, spina bifida, etc.; (2) in diseases such as diabetes, syphilis, alcoholism, etc., which lead to peripheral neuritis; and (3) as a sequence of traumatic lesions of the nerves affecting any portion of their course from the spinal cord downwards. (4) Perforating ulcer is occasionally due to pure plantar lesions, apart from any nervous influence, *e.g.*, a suppurating wart or corn, or even a chronic epithelioma. The skin under the head of the first metatarsal is the part most frequently affected, but any spot to which undue pressure is directed may become involved, and not uncommonly several such sores may be seen on the same foot. A corn or callosity first forms, and under this a bursa, in which suppuration takes place; the pus, finding a difficulty in coming to the surface owing to the thickness of the cuticle, spreads deeply into the soft structures of the sole, and the suppuration may even involve bones and joints. A typical perforating ulcer presents the appearance of a sinus passing down to the deeper parts of the foot, and even extending through to the dorsum; the orifice is surrounded by heaped-up and thickened cuticle (Fig. 136). There is sometimes but little discharge and often no pain, but when bones or joints are affected, free suppuration may occur. If allowed to progress without treatment, the bones and joints of the foot may be destroyed extensively, or may be welded together into a solid painful mass, in either case necessitating amputation. A cure can sometimes be determined in the early stages by removing the thickened mass of cuticle and purifying or excising the sinus; the cavity thereby formed is packed with gauze and allowed to heal by granulation. Should this fail, or if bones or joints are involved, amputation will be required.

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* The following is a useful formula:

℞. Acidi salicylici, gr. xv.
Ext. cannabis ind., gr. viii.
Sp. vini rect., ♏xv.
Ætheris, ♏xl.
Collodion flexile, ♏lxxv.
M. Ft. pigm.

Sig.: To be painted on with a brush three times a day for a week.—R. CROCKER.

A **Wart** (*verruca*) is a papillary overgrowth of the skin, which may manifest itself in many different appearances. The common wart is a horny projection about the size of a split pea, usually seen on the hands of young people; its surface may be smooth or irregularly filiform, and its colour varies with the amount of dirt ingrained on the surface. When smooth-topped, they are sometimes extremely numerous, and may be a little difficult to distinguish from lichen planus. In parts where there is a certain amount of moisture warts become soft in character, and form large vascular masses—*e.g.*, venereal warts. The best method of treating ordinary warts is to paint them with glacial acetic acid, or some other caustic, every two or three days, after softening and removing the horny crust with salicylic acid. Ionic treatment with salicylates is also of value.

Verruca Necrogenica (see p. 251).

A **Chilblain** (*pernio*) is an inflammatory hyperæmia, usually involving the fingers, toes, or ears, and determined by exposure to cold. It is generally seen in young people with defective circulation, whose fingers and toes easily go dead. After the period of anæmia and pallor, the part begins to itch or burn, and becomes red, swollen and shiny. Exudation occurs into and beneath the skin, and in bad cases a blister with blood-stained contents forms; when this bursts, troublesome ulceration ensues. To prevent the formation of chilblains the patient's circulation must be improved, and exposed parts kept warm. In the earlier stages treatment by induced hyperæmia is most valuable; an elastic bandage may be worn for six hours or so daily, whilst locally the parts may be painted with tincture of iodine or a solution of ichthyol. When the chilblain breaks, simple antiseptic precautions may suffice, but a more stimulating application is usually required, and Peruvian balsam or resin ointment will be found useful.

Tuberculous Affections of the Skin.—**Lupus Vulgaris** is a chronic inflammation of the skin of tuberculous origin. It is met with in children and young adults, rarely commencing after the age of thirty. Its most common situation is the face, generally starting on the nose or cheek. It is rare on the scalp, but fairly frequent on the trunk and extremities. The mucous membrane of the nose and mouth is also attacked, but usually by extension from the skin. It is not often symmetrical, except when commencing on the nose.

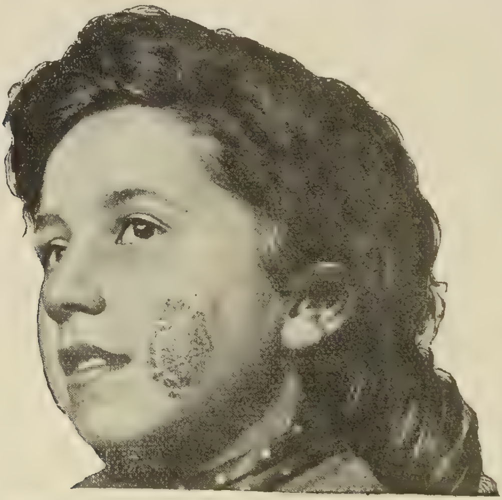

FIG. 137.—NON-ULCERATING LUPUS OF CHEEK. (FROM A PHOTOGRAPH.)

Clinical Features.—The earliest manifestation of lupus consists in the formation of one or more shot-like nodules in the deeper layers of the skin, which are surrounded by a zone of hyperæmia and infiltration. These nodules are not particularly hard to the touch, but when of any size can be demonstrated to be of a brownish-orange tint, especially if they are devascularized by the pressure of a glass slide, and then the colour somewhat resembles that of apple-jelly. Gradually the process extends, and usually more rapidly in one special direction, following the course of the vessels. At the same time the integument becomes infiltrated and transformed into granulation or cicatricial tissue, covered by a layer or two of epithelium (Fig. 137), and owing either to degeneration of the tuberculous nodules, or to a lack of vitality, arising from compression of the vessels by the contraction of this new formation, ulceration is very liable to follow. In the extremities the lupoid growth not unfrequently takes on a warty aspect, somewhat similar to the 'anatomical wart' occasionally seen on the knuckles of post-mortem porters (p. 251).

A *Lupoid Ulcer* usually spreads at one margin as it heals at the other, and hence under typical circumstances is more or less crescentic in shape. The surface is covered with granulations, often of a protuberant nature. The edges are raised and infiltrated, and scattered lupoid tubercles are readily distinguishable, extending into the healthy tissues, which are usually red and congested. A considerable amount of sero-pus is often secreted, and this by drying forms thick scabs. Any cicatrix which results from natural processes of cure is thin and vascular, easily breaking down from slight irritation. The process extends gradually, with or without intermissions, from the seat of its first appearance; it is as a rule limited to the cutaneous tissues; but when it attacks the nose, the cartilages are often involved and destroyed, whilst if it involves the palate or septum nasi, perforation is very likely to ensue. The disease is practically painless, and does not at first affect the general health. Neighbouring lymphatic glands may become inflamed, and in a few instances are the seat of a tuberculous deposit. Left to itself, it tends sooner or later to come to an end, the ulcerated parts cicatrizing, but leaving indelible traces of its ravages in the shape of obvious scars, with often considerable loss of substance. Occasionally it persists, in spite of treatment, and then an epithelioma may in time develop on the site of the mischief, running a rapid course owing to the vascularity of the part.

Pathological Anatomy.—The characteristic microscopical feature of lupus lies in the formation of nodules around the smaller vessels of the skin (Fig. 138), consisting chiefly of a mass of round cells, within which may perhaps be observed a giant cell and endothelioid cells, arranged in the same way as in tubercle. The structures around are infiltrated and hyperæmic; as the disease progresses, the original tissue of the part disappears, and is replaced by granulation or fibro-cicatricial tissue. The bacilli are by no means readily found, and are always few in number.

The **Diagnosis** of lupus from syphilitic and other destructive affections of the skin turns on the presence of outlying nodules beyond the spreading edge of the lesion, together with the apple-jelly-like granulations, and the thin, congested character of any cicatricial tissue present, whilst the slow, though continuous, progress, and the tendency to heal at one part as it spreads at another, are also suggestive of its presence. The age and constitution of the individual, and the persistence of the disease in spite of treatment, must also be taken into account.

The **Treatment** of lupus has been greatly modified of recent years, owing to the discovery of the remedial properties of Finsen light, X rays, and other agents. Of course where practicable, excision of the whole area of disease is the quickest and safest cure; but it is seldom available.

In the *Finsen-light cure* (p. 51) each sitting lasts for one and a quarter hours, and an attendant whose eyes are shielded by dark glasses controls the crystal water-chamber, keeping it firmly against the skin, and slightly shifting it from time to time so that an area about as large as a shilling shall be acted upon at each séance. Slight inflammatory phenomena follow, and a local leucocytosis supervenes, as a result of which the disease disappears, and a soft supple scar is produced, which is very little obvious. It has been found of most value where ulceration is absent and the patch not of great size.

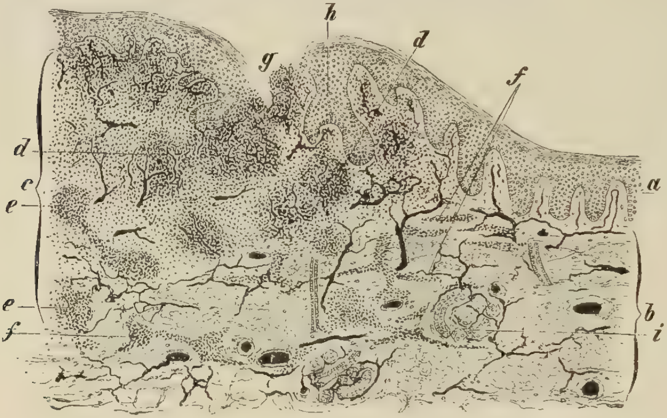

FIG. 138.—SPREADING MARGIN OF A PATCH OF LUPUS. (ZIEGLER.)

a, Normal epidermis; *b*, normal corium with sweat-gland (*i*); *c*, focus of lupoid tissue; *d*, vascular nodule surrounded by diffuse cellular infiltration; *e*, non-vascular nodule; *f*, strings of cells in course of lymphatics; *g*, lupoid ulcer; *h*, proliferating epithelium.

X-ray treatment is also valuable. The same precautions as to protecting healthy parts must be observed as in treating cancer (p. 57). The best results have been obtained by using a tube of comparatively low vacuum, and by working for a definite inflammatory reaction, and then stopping till this has disappeared. The length of the treatment necessarily varies, but, as a rule, three to six exposures a week of not more than ten minutes each will suffice. The X rays appear to act best on the ulcerative and fungating forms of lupus, which clear up and heal; but the cure is only up to a point, as the scars are frequently found to contain small nodules over which the rays have no further influence. For these the Finsen light may be employed beneficially; but in the absence of this agent they should be dealt with by scraping with a lupus spoon, and subsequently applying solid nitrate of silver, acid nitrate of mercury on a match end, chloride of zinc as a paste, or even the actual cautery.

In some bad cases with much ulceration and when there is a superabundance of granulations it may be wise to remove these with a sharp spoon as a preliminary measure, and then hand the patient over to the radiographer. The surgeon must remember, however, that he is not operating to cure the disease, but merely to lay bare the deeper tissues in order that the rays may reach them more effectively. He must not include in the scope of his operation healthy tissues.

Tuberculin probably renders the disease more amenable to local measures, and prevents recurrence after its destruction, but by itself seldom cures. The patient's health also must be attended to, and a course of suitable tonics administered. An open-air life, as nearly assimilated to the sanatorium type as possible, is also desirable.

Lupus Erythematosus is a disease the nature of which is not yet satisfactorily determined. The appearance of the affection is tolerably characteristic; it is usually situated on the face, and in the most typical cases symmetrical patches are formed over the root of the nose and cheeks, corresponding in appearance to a butterfly with outspread wings. The condition frequently invades the forehead ears, and scalp, and occasionally appears on the trunk, being then unilateral. It appears as a smooth hyperæmic surface, covered with a branny desquamation; the scales consist of inspissated sebum, and are continuous with deep plugs, which can be traced into the mouths of enlarged sebaceous follicles. As the disease spreads peripherally, the older and central portions are transformed into cicatricial tissue of a pale, thin and white type, in marked contrast to the hyperæmic condition of the advancing margin. It is usually seen in adults, and more frequently in women than men. Progress is exceedingly slow, and ulceration uncommon, except when the ears or scalp are involved; in the latter region the hair is often lost. Epithelioma has also been known to follow this affection.

The **Treatment** consists in attention to the general health, together with the local application of weak tarry and mercurial preparations. The X rays and Finsen light act rapidly, but must be used with caution, since the inflammatory disturbance caused by them is considerable.

The so-called **Tuberculous Ulcers** differ from the lupoid in the fact that they always result from the breaking down of a subcutaneous focus, and hence may be connected with diseases of bones, joints, lymphatic glands, or simply of the connective tissues. Their characters and treatment have been already indicated (p. 183).

Other cutaneous manifestations of tubercle are recognised, but need scarcely be mentioned here.

Affections of the Nails.

A **Paronychia** (panaritium, or 'run around') is a condition frequently seen in surgeons, nurses, or others who have to expose their hands to infective material, as a result of infection of the semilunar fold at the base of a nail. It is often preceded by a 'hang-nail' which gives entrance to the organisms, and the patient's general condition may be unsatisfactory; not uncommonly, however, it is seen in hospital nurses and others who have just returned from a holiday, suggesting that they need to become immunized to their surroundings. The skin at the side of the nail becomes swollen and hyperæmic, and on pressure is tender to the touch; gradually the pain increases and is particularly troublesome at night, perhaps preventing sleep. A certain amount of discharge may occur through the semilunar fold, but a sufficient exit is rarely given by natural processes. Unless effective treatment is undertaken, the suppuration spreads around the root of the nail to the other side, and also burrows beneath the nail, separating it from the matrix. Granulations spring up freely from the semilunar fold, and thereby discharge is often prevented from escaping.

Treatment in the early stages is by fomentations and the use of a Klapp's suction-ball; the skin at the side of the nail is pared down, and if pus appears, a longitudinal incision parallel to the margin of the nail through the inflamed tissues will give exit to the pus, and often suffices to cure the case. If the pus has burrowed beneath the nail, one or more incisions must be made radially through the semilunar fold (Fig. 139), so as to expose the base of the nail, and permit all the loosened portion to be cut away from the matrix by sharp scissors; in some cases all the base of the nail has thus to be sacrificed. The terminal portion may, however, be left, as it is serviceable while the new nail is forming. Abundant granulations spring up from the matrix, and these may need to be kept in check by nitrate of silver.

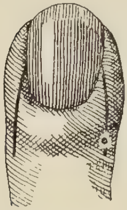

FIG. 139.—INCISIONS FOR TREATMENT OF PARONYCHIA.

Onychia Purulenta is the term applied to a suppurative lesion of the nail matrix which results in the destruction and separation of the whole nail. It may commence on one side as a paronychia, or may be due to infection of the matrix by penetrating foreign bodies. It also occurs in tuberculous and syphilitic children where the matrix is transformed into granulation tissue with but little suppuration, and the whole digit becomes swollen and bulbous (*onychia maligna*). *Treatment* consists in avulsion of the nail, and in syphilitic cases this must be supplemented by the administration of mercury generally, and the application of an oleate of mercury ointment (5 per cent.) locally.

Ingrowing Toenail is an ulcerated condition of the soft parts projecting over the side of one of the toenails (usually that of the great-toe), and due either to the pressure of pointed or badly-fitting boots, or to neglect in trimming the nails. The fold of skin is thus pressed by the boot over and against the nail when the patient walks, and in order to diminish the pain and irritation caused thereby, he often cuts away the projecting angle of the nail, but leaves a deep corner which still further irritates the soft parts. Ulceration ensues, accompanied by an offensive discharge and so much pain as to prevent the patient from walking. The matrix of the nail may also become inflamed, and onychia result. In the earliest stages, further progress can often be prevented by careful attention to the nails, by the use of square-toed boots fitting easily, and by introducing small plugs of aseptic wool to press back the overhanging fold of skin. A cure can sometimes be effected by excising an oval portion of skin from the side of the toe and close to the nail. The edges of the incision are drawn together by horsehair, and thus the overgrowing fold of skin is drawn away from the nail (Fig. 140). When ulceration is actually present, the best treatment is the removal of the affected half of the nail, giving special attention to the extraction of the projecting angle. If there is much discharge, it is also wise to cut away the overhanging fold of skin with scissors, and scrape away any granulations present. The parts are then dressed antiseptically, and in a few days the patient is able to walk about.

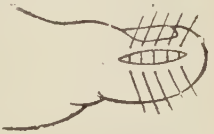

FIG. 140.—OPERATION FOR INGROWING TOENAIL.

The term **Onychogryphosis** is applied to a hypertrophic condition of the nails, which become distorted and bent, or twisted up, perhaps simulating a ram's horn. It is usually limited to the great toes of elderly people, and is due to neglect. The nails are very rough, and often covered with grooves or ridges, whilst beneath them is an accumulation of soft, offensive epithelium. The only treatment is removal.

Affections of the Sebaceous Glands.

Sebaceous Cysts occur on any part of the surface of the body, but, especially the scalp, and are due to obstruction of the duct of a sebaceous gland. They are rounded swellings, firm and elastic to the touch, moveable on the deeper structures, and always attached at one spot to the skin. On careful examination, the obstructed mouth of a sebaceous follicle can usually be seen, and possibly some of the contents of the sac squeezed through this opening. The cyst wall is formed by several layers of epithelium, surrounded by dense fibro-cicatricial tissue, and if exposed to irritation or pressure, as when situated on the back or shoulder, and rubbed by the braces, becomes very firmly adherent to the surrounding parts. The material contained within is of a cheesy, pultaceous consistency, with a peculiar stale odour, yellowish-white in colour, and under the microscope is seen to be composed of fatty and granular débris, epithelial cells, and cholesterine. Left to themselves, the cysts may attain considerable dimensions, whilst the walls and contents sometimes become calcified. Occasionally the exudation oozes through the duct, and dries on the surface, with just sufficient cohesion to prevent it from falling off; layer after layer of this desiccated material is deposited from below, finally giving rise to what is known as a **Sebaceous Horn.**

These become dark in colour from admixture with dirt, and are always more or less fibrillated in texture; the base, to which they are firmly adherent, is infiltrated and hyperæmic. Sebaceous cysts sometimes inflame and suppurate; sooner or later they burst or are opened, and then the process subsides. They are sometimes cured in this way, but more frequently the cyst fills up again, and the same series of phenomena are repeated after an interval. Should the contents only escape partially, the remainder is liable to undergo putrefactive changes, giving rise to an offensive ulcerated surface with raised edges, which may readily be mistaken for epithelioma. It is sometimes known as *Cock's Peculiar Tumour*. True malignant disease of an epitheliomatous nature is said occasionally to supervene.

Diagnosis.—From a *dermoid cyst* it is known by the facts that the dermoid is congenital in origin, that it is limited to certain localities, whilst it is hardly ever directly attached to the skin. From a *fatty tumour* it is recognised by its rounded shape, its fixity to the skin, the absence of lobulation, and by its more solid character, whilst a lipoma is softer and more moveable. From a *chronic abscess* it is distinguished by the dilated orifice, by its firmer consistency, and by the history, but it is sometimes impossible to be certain before incising it.

Treatment.—A sebaceous cyst should be entirely and completely removed if giving rise to any disfigurement, inconvenience, or pain. In the scalp all that is needed is to transfix the tumour, squeeze out the cheesy contents, and then the cyst wall can be readily removed by grasping it with dissecting forceps and pulling it away. In other situations the cyst wall may require to be dissected out; but even then it is advisable to open it by transfixion, and to deal with the sac from within. Horns and fungating ulcers should be excised with the surrounding skin.

Sometimes a true **sebaceous adenoma** may develop in connection with these cysts. It may be slowly-growing and of a firm, solid consistency; but sometimes it is much more vascular and grows rapidly. The latter has a form of semi-malignancy in that it is very liable to recurrence, and has therefore often been mistaken for a sarcoma. On microscopic section it closely resembles a rodent ulcer, but its clinical history is quite distinct. Its most frequent situation is the scalp, and it requires to be removed with a free hand, the defect in the scalp being made good by Thiersch-grafting.

Molluscum Contagiosum.—This affection shows itself in the form of a number of firm hemispherical nodules, a little larger than a split pea, usually of a yellowish-white colour, and very definitely umbilicated. The depression in the centre may be occupied by dry débris, and from the larger ones a waxy mass can be expressed. They are usually seen on the face, but may involve any part of the surface of the body. There seems no doubt as to their contagious properties, this being perhaps best seen in the development of growths of this nature on a mother's breast, secondary to those on the face of her baby, but the cause of the contagion is by no means certain. Pathologically, the tumours consist of numerous wedge-shaped lobules of polygonal, nucleated, epithelial cells, supported by a fibrous stroma. The cells towards the centre undergo a waxy or hyaline degeneration, and in them are seen numerous rounded bodies, which have been supposed to resemble psorosperms. *Treatment* consists in cutting or pulling them away, or in cutting them across, and squeezing the contents out from the well-defined capsule.

Rodent Ulcer is a special variety of glandular cancer, commencing either in the sebaceous glands or in the basal layer of the rete Malpighii. It is usually met with in elderly patients, though occasionally observed in those under forty, and is seen with special frequency on the upper two-thirds of the face, the skin below the inner and outer canthi being the chief seats of election. It commences as a papule or flat-topped nodule in the skin, surrounded, perhaps, by an area of hyperæmia. The infiltration extends gradually in all directions, but the ulceration usually keeps pace with the new growth. The ulcer has a smooth but somewhat depressed surface, is perhaps covered with granulations, and bounded by a slightly raised, indurated, rolled-over edge (Fig. 141). In most cases one can detect evidences of the new formation beneath the skin beyond the edge. If kept aseptic, there is but little discharge, and imperfect attempts at cicatrization are often observed, the scar, however, readily breaking down; but when septic, the surface is covered with sloughs, and an abundant offensive discharge escapes. The condition is painless; neighbouring lymphatics are not enlarged, and the general health does not suffer, except in the later stages. The progress of the case is slow, but continuous, and although it spreads for a time super-

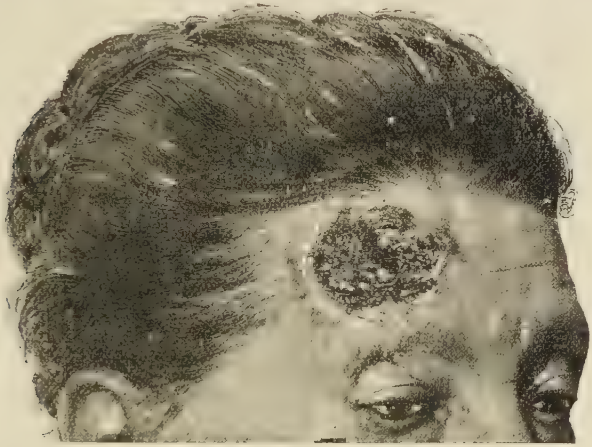

FIG. 141.—RODENT ULCER OF MANY YEARS' STANDING.
(FROM A PHOTOGRAPH.)

ficially rather than deeply, sooner or later underlying structures become involved, and then nothing hinders the destructive process, even the bones of the skull being eroded, and the dura mater exposed.

Microscopically, the growth consists of interlacing columns of epithelial cells, interspersed with fibro-cellular tissue (Fig. 142). The constituent cells are small, globular, and closely packed, never of the 'prickle-cell' type, and rarely show signs of keratinization; hence 'cell-nests' are uncommon, although they are sometimes observed. The cells of the peripheral layer, however, are often elongated, and arranged side by side like a palisade. The deep processes spread laterally rather than deeply beneath the unaffected skin, the papillæ of which are atrophied; their outline is clearly defined, and frequently angular on section. There is but little infiltration of round cells around the epithelial columns.

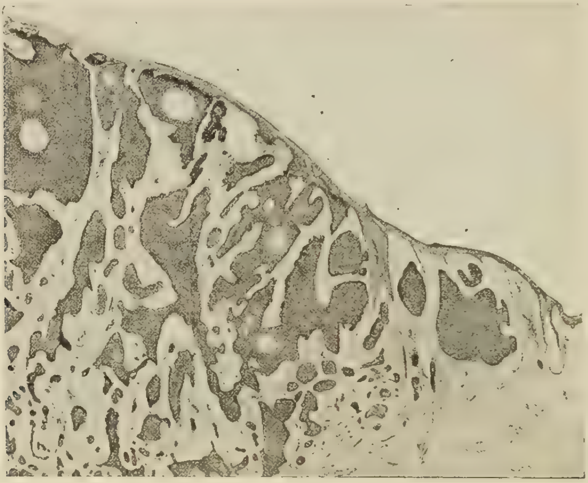

FIG. 142.—RODENT ULCER. (PHOTOMICROGRAPH, × 30.)

The **Treatment** of rodent ulcer has been considerably modified of late. Formerly the method of choice consisted in free excision when practicable, a margin of *at least* half an inch being allowed all round, and the defect made good by skin-grafting or by some plastic operation. Where this could not be undertaken, the ulcer was thoroughly scraped, and the surface treated with nitric acid, chloride of zinc paste, or some other caustic, the wound being allowed to heal by granulation.

The discovery of the therapeutic value of the X rays has considerably diminished the number of cases operated on for this disease. The sore or nodule is exposed to the influence of the rays for about ten minutes daily, and a reaction of variable intensity follows, which results in many cases in the surface of the sore cleaning up and healing. Recurrence is occasionally observed, but the recurrent nodules can be treated in the same way. Of course, surrounding parts have to be carefully protected.

Radium bromide has also proved serviceable in some cases. It is best applied in a lead capsule with a mica window, and 5 or 10 milligrammes is the usual quantity employed. This capsule is enclosed in a piece of sterilized gutta-percha tissue and fixed over the diseased area with strapping. It may be applied for a short time (five or ten minutes) daily, but acts equally well if applied for half an hour once a week. The reaction varies considerably with the quality of the radium, but sometimes an inflammatory reaction of some intensity follows. Treatment by *zinc ions* (p. 54) has also been found useful, especially in patients who can only come for treatment occasionally. The process is painful, and it is well to introduce cocaine as a preliminary by moistening the positive pad with a solution of the hydrochlorate. The rodent ulcer is then covered with several layers of lint wet with a 2 per cent. solution of sulphate or chloride of zinc, and the positive electrode is applied over this.

Our present experience seems to indicate that superficial growths are best treated by X rays, whilst the deeper ones are more amenable to the action of radium or zinc ions. The scar left after treatment by any of these agents is of a most satisfactory type, being soft, supple, and often not at all obvious, and hence this treatment is particularly indicated when the disease affects the eyelids or front of the face. In other places it may be possible to remove the greater part of the disease with the knife, and the rays may then be used with advantage to the raw surface before grafting is undertaken. When bone or cartilage is affected, operation is the only hope, as, although improvement follows the use of the rays, recurrence is almost invariably the rule.

CHAPTER XVIII.

AFFECTIONS OF MUSCLES, TENDONS, AND BURSÆ.

Injuries of Muscles and Tendons.

Contusion.—Muscles are bruised as a result of blows or falls, leading to more or less extravasation, with possibly some rupture of the fibres. The part becomes tender and swollen, and any active contraction gives rise to pain; passive movement, however, is tolerated, if the injured fibres are not thereby put on the stretch. Fomentations and rest may be needed for a few days; but regular massage, and perhaps elastic support, are subsequently necessary.

Sprains and Strains, due to violent efforts or falls, result in the tearing or stretching of some of the fibres. Considerable stiffness follows, especially in rheumatic and gouty patients. Rest and either hot or cold applications may be used at first; but elastic pressure and regular massage will be needed later. In individuals predisposed to the development of tuberculous disease, special precautions must be taken to ensure complete recovery.

Rupture of the Sheath of a muscle is an accident occasionally met with, especially in the adductors and rectus abdominis. The belly of the muscle, when contracted, protrudes through the opening as a hernia, constituting a soft semi-fluctuating swelling. In treating this condition the limb must be kept at rest in such a position as to relax the muscular fibres and allow the rent in the fascial sheath to heal. In old-standing cases it is justifiable to cut down upon and expose the opening in the muscular sheath, the edges of which are sutured together, or if this cannot be effected a sterilized sheet of silver foil may be stitched over the defect.

Displacement of Tendons rarely occurs, except in parts where these structures pass through osseo-fibrous canals, and particularly in those where the line of action is thereby changed. During some violent effort the patient feels a sudden localized pain, followed by a certain amount of limitation of mobility. This accident is popularly known as a 'rick.' In superficial parts the displaced tendon can sometimes be distinctly felt in an abnormal position, and this becomes more evident on attempting to move it. Thus the long tendon of the biceps may be dislocated from the bicipital groove; and various tendons about the wrist or ankle, especially that of the peroneus longus, may similarly suffer. If left alone, the parts settle down more or less comfortably, but some permanent weakness may persist; recurrence is very likely to ensue if movement is permitted before the newly-formed connections have had time to consolidate.

Treatment consists in fully relaxing the muscles and replacing the tendon, if possible, by manipulation. The parts are then immobilized for six or eight weeks by a plaster of Paris splint or strapping. If the displacement recurs, it is sometimes advisable to expose the tendon, and stitch it back into position, using early passive movement to prevent the formation of troublesome adhesions. This is required most frequently in the case of the peroneus longus tendon, which slips forwards from its groove behind the external malleolus. The external annular ligament is thereby ruptured, and the operation consists either in suturing the divided segments, or in more aggravated cases it may be necessary to turn down a flap of periosteum from the malleolus, and by stitching its apex to the outer side of the os calcis secure the tendon in place.

Rupture of Muscles and Tendons is by no means uncommon, resulting from excessive violence of a sudden and unexpected nature. Most frequently the tendon gives way at its union with the muscular belly; less often the belly itself yields, whilst occasionally the tendon may snap, or the point of bone to which it is attached may be torn off.

Signs.—The patient at the moment of the accident experiences a sharp and severe pain, as if he had been struck with a whip; he may also feel or hear a snap. Loss of function follows, together with a certain amount of swelling and bruising, which is more evident if the muscular fibres have been torn across than if the tendon alone has been lacerated. On attempting to contract the affected muscle, the belly rises up as a soft, rounded, semi-fluctuating tumour, drawn towards the uninjured attachment, if the union between the tendon and belly has given way; whilst if the lesion has been through the muscular substance, the divided halves of the belly become similarly prominent, and a distinct gap or sulcus can be felt between them.

Repair is established in the usual way by the formation of granulation, and finally of cicatricial tissue. Where a muscular belly is involved and the ends are much separated, a long and weak bond of union is likely to form; but when they are closely apposed, the cicatrix is short, and may be replaced subsequently by true muscular tissue. When a tendon has been divided or torn, the connecting medium is at first attached to the sheath, and if this adhesion persists, it may lead to pain and weakness. It is an interesting fact to note how rapidly this tissue becomes strong; a rabbit's tendon ten days after division requires a weight of 56 lbs. to break it (Paget).

Treatment.—It is essential to relax the parts fully so as to limit the separation of the divided ends, and to maintain them in this position for two or three weeks. Any resulting stiffness is combated by passive movements and massage, whilst, if need be, adhesions are broken down under an anæsthetic. Tendons accidentally divided in open wounds should be sutured together by silk or catgut, careful antiseptic precautions being adopted to prevent suppuration along the tendon sheaths. Where there has been actual loss of substance in a tendon, one may be split longitudinally in such a way as to leave a thin flap attached peripherally, so that the free end can be turned down and united to the other segment (Fig. 143); or similar flaps may be provided from each end (Fig. 144); or it is possible to remedy the defect by grafting a portion of tendon from another region or person, or from an animal, between the two ends. Care must be exercised to prevent opposing muscles from dragging on and stretching the new bond of union, as thereby considerable functional disability may result. Thus, a young man had his anterior tibial muscles divided by a stab with a knife; they were carefully sutured together, but during convalescence the foot was allowed to drop, the result being that the muscles and tendons were stretched, and hence the most vigorous contractions had no effect in raising the toes, which dragged along the ground. A second operation to shorten all these structures was required.

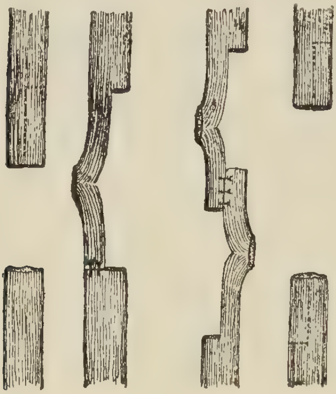

FIG. 143. FIG. 144.

METHOD OF UNION OF TENDON AFTER LOSS OF TISSUE.

In Fig. 143 the flap is taken from one end only; in Fig. 144 from both ends.

Muscular bellies which have been divided longitudinally or obliquely are easily united by sutures; but when the section is transverse, the stitches tend to cut out, unless the sheath can also be secured. In such a case it is advisable to encircle with a ligature a bundle of muscular fibres on either side of the incision, and then tie the two threads together. This must be done at several spots in the cross-section.

The *long tendon of the biceps* is not unfrequently torn from the muscular belly, which, on attempting to bend the arm, is drawn down towards the elbow, constituting a soft tumour, somewhat resembling a lipoma. No special treatment is needed beyond keeping the fore-arm flexed for a time. If the *tendo Achillis* is ruptured, union may be attained by keeping the knee bent and the heel raised, as by securing a strap to the back of a slipper below, and to a dog-collar or suitable strap passed round the knee above. A better result, however, would follow an aseptic incision and suture. Similarly, if the *ligamentum patellæ* is torn across, suture through an open wound gives the best result. The *inner head of the gastrocnemius* is sometimes torn in wrenches or slips, as at lawn tennis, and the *plantaris* is similarly affected. Cooling lotions are applied for a few days, and the parts are kept at rest until the tenderness and swelling have in a measure subsided, and then regular massage is undertaken. The *adductor longus* may be lacerated in violent attempts to maintain a seat on horseback, and constitutes one form of rider's sprain; it is treated by rest and the application of a firm spica bandage, but in bad cases operation may be required.

The *long tendons of the fingers* are not unfrequently divided accidentally, and unless they are effectively sutured considerable impairment of function will result, the finger remaining in a position of flexion or hyper-extension, according to whether the extensors or flexors are involved. Operation to secure the divided ends should be undertaken at the earliest possible moment, but not until suitable aseptic conditions are present. Owing to the existence of a sheath the *flexor tendons* retract considerably, and a longitudinal incision in the middle line of the finger may be required to reach the proximal end. Its position can be indicated by the passage of a probe up the sheath, which is *incised only opposite the retracted end of the tendon.* A suture is introduced into the tendon and carried down the sheath, and thereby the retracted tendon is drawn again to the site where it was divided and secured to the distal end. By this manœuvre an extensive incision of the sheath is avoided, and adhesions are minimized. The finger must subsequently be kept in a splint, and active movements are not permitted for ten days.

The *extensor tendons* have no synovial sheath on the fingers, and hence there is but little difficulty in securing them by suture, except when the attachment to the terminal phalanx is torn through, a not uncommon accident. The aponeurosis retracts and the thickened divided end can be felt opposite the centre of the second phalanx; the terminal phalanx is bent and constitutes the condition known as a *mallet finger.* Fixation of the finger in a position of extension is useless in this condition, as approximation of the tendon to its point of attachment is not effected. Open operation is often unsatisfactory, since the tendon is torn completely away from the bone, and there is nothing to which to fix it. Good results are often obtained even at a comparatively late stage by putting up the finger with the metacarpo-phalangeal and first interphalangeal joints fully flexed, the second interphalangeal joint being extended —an uncomfortable position at first. The extensor aponeurosis is so attached that flexion of this type drags it downwards and relaxes its terminal segment so that satisfactory union is by this means much more likely to occur.

It is sometimes important and often difficult to differentiate between a divided tendon with retraction of the segments, an adherent tendon, and one which has been destroyed by sloughing; particularly is this the case in connection with the flexors of the fingers. *Division* of a tendon involves loss of active movement alone; the finger can be moved passively, but immediately springs back into the old position. *Adhesion* of a tendon to its sheath or in the palm involves more or less flexion of the finger and stiffness; attempts to straighten it are painful, and cause the tendons above the wrist to be dragged on. *Sloughing* of the flexor tendon results in flexion from contraction of scar-tissue, together with wasting and impairment of nutrition of the finger. Attempts at extension produce no result either on the finger or on the tendons above the wrist. Sloughing of the extensor tendon also results in the finger becoming bent from unbalanced action of the flexors.

The persistence of any of these conditions is followed by changes in the interphalangeal joints and their ligaments which may invalidate the success of subsequent operations. Under such circumstances it may be necessary to include a resection of the joint at the same time as the tendons are reunited. Where there is much loss of substance, tendon-grafting may be required, or the finger may be shortened by suitable excision of bone.

Diseases of Muscles.

Inflammation of Muscles (Myositis) may arise from a variety of circumstances, but the chief results are alike, whatever the cause, viz., a more or less painful infiltration of the muscle, with increased discomfort on attempting movement. The part feels hard and rigid, and may be tender to the touch. If suppuration ensues, the ordinary signs of an abscess subsequently make themselves evident. A certain amount of contractile tissue is thereby destroyed, and the cicatricial changes induced will possibly lead to deformity.

Varieties.—1. **Simple Traumatic Myositis** results from contusion or laceration of the fibres, and is merely a plastic inflammation, with or without hæmorrhage, running on to resolution, with perhaps a little fibroid thickening of the part. It is liable in some cases to become chronic, the muscle substance becoming shortened and replaced by fibrous tissue (*M. fibrosa*), and this fibrosis may extend beyond the limits of the original lesion. The induration of the sterno-mastoid muscle met with in children is of this type, and may lead to torticollis.

2. **Rheumatic Myositis,** or muscular rheumatism, is a condition often met with, especially in middle-aged men of rheumatic or gouty temperament who are unable or unwilling to take a sufficiency of exercise, and who live well. The condition apparently involves the fibrous tissues mainly—*e.g.*, the fasciæ, aponeuroses, tendons, and sheaths of muscles, or the ligamentous tissues of joints; hence the name *fibrositis* is often applied to it. Some forms of neuralgia result from a similar affection of nerve sheaths (perineuritis). Any part of the body may be involved, but in particular may be noted *lumbago*, in which the fascia lumborum is affected, the patient walking with a stiff back slightly flexed; the pain often starts suddenly during some effort, and when present any unexpected movement elicits a sharp spasm. Rheumatic wry-neck is a similar condition, and may be induced by exposure to a draught. Pains in many joints—shoulders, knees, tendo Achillis, etc.—are of a similar nature, and sometimes are distinctly influenced by climatic conditions.

Treatment.—A good dose of calomel is in many cases desirable at the start, followed by suitable dietetic or medicinal remedies directed to the rheumatic or gouty basis of the trouble. Iodide of potassium is by some authorities looked on as always desirable. In the more active stages the part must be kept at rest, and dry or moist heat applied to relieve pain, whilst aspirin may be given for a similar purpose. Various methods of applying radiant or other forms of heat have been already alluded to (Chapter III.). Vibro-massage is in many cases most valuable. Hydrotherapy, when it can be utilized, is exceedingly useful, and the patient must be subsequently instructed to take more exercise and to live more simply.

3. **Acute Suppurative Myositis** is the outcome of infection with pyogenic organisms, either from without, as after operation wounds, penetrating injuries, etc., the pus in such cases spreading widely up and down the muscular planes; or from within the body, as in pyæmia; or by extension from neighbouring suppurative foci, as from subperiosteal abscesses; it may also arise after a contusion or sprain by auto-infection. Great cicatricial deformity is likely to follow.

4. **Chronic Tuberculous Myositis,** with the formation of a chronic abscess, is not an uncommon secondary consequence of a similar affection of neighbouring bones or joints—*e.g.*, a psoas abscess.

5. **Syphilitic Disease** is usually met with in the tertiary period, and takes the form either of a diffuse sclerosis or of a localized gumma. Any muscle may be affected, but perhaps the tongue and sterno-mastoid are those most frequently involved. Care is needed in making a diagnosis, since these conditions resemble tumours in their method of onset; but the presence of a syphilitic history, the slow growth, the hardness with subsequent central softening, and the rapid disappearance after the administration of iodide of potassium, should suffice to determine their nature.

Occasionally gummata appear in muscles in the shape of small hard and shotty nodules, usually arranged more or less longitudinally, which are painless and apparently attached to the fascial sheath. They react readily to iodide of potassium.

6. **Parasitic Myositis,** arising from the presence either of the *Trichina spiralis* or of hydatids, need not be described here.

7. **Myositis Ossificans** is a rare disease, in which various muscles, especially those of the back, are transformed into bony plates or rods, so as to lead to extensive ankylosis. The process seems to be one of ossification of the connective tissue associated with atrophy of the muscular fibres, and is sometimes extremely painful. It is most commonly seen in young males, and is possibly rheumatic in origin. In a boy under observation the arms were immobilized by ossification of the latissimus dorsi muscles on either side, whilst the pectoralis major was also ossified on the right side. The erector spinæ was involved, the back being rigid, and the right trapezius was undergoing the same change. This disease is often associated with a congenital deformity of the great toes in which the proximal phalanx is absent or stunted. No treatment has proved of any value.

Quite distinct in nature is the *Traumatic M. Ossificans*, of which two varieties are described: (i.) The new formation results from persistent and repeated irritation of muscles or tendons, and usually starts from the periosteal attachment. The 'rider's bone' developed in the tendon of the adductor longus is of this description. (ii.) Less commonly the affection follows a severe injury to a muscle and is often secondary to a fracture or dislocation. Extensive hæmorrhage follows, leading to the formation of much fibrous tissue, and in about three to four weeks the presence of bone can be recognised by palpation or radiography. Some painful limitation of movement may ensue, but if possible the condition is left alone, unless the disability is great, and then removal must be undertaken. The muscles in which this type of inflammation has been most commonly observed are the quadriceps femoris and the brachialis anticus (Fig. 145).

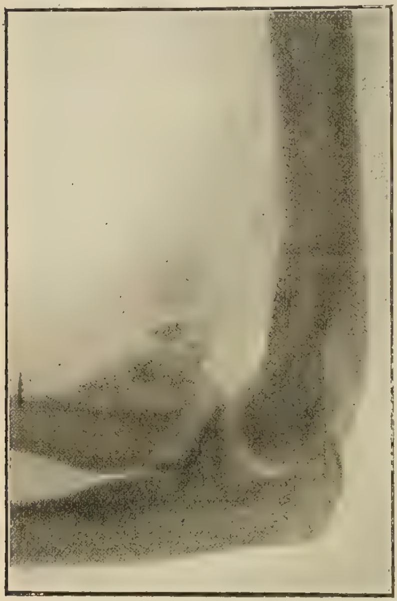

FIG. 145.—RADIOGRAM OF TRAUMATIC MYOSITIS OSSIFICANS INVOLVING THE BRACHIALIS ANTICUS. (LENT BY DR. KNOX.)

Tumours of Muscles are not very common. Primary growths consist of angioma, lipoma, fibroma, chondroma, myxoma, or sarcoma, and of these the majority start in the fibrous sheaths or the interfibrillar connective tissue. Secondary deposits of both carcinoma and sarcoma also occur. **Treatment** is conducted on ordinary surgical principles. If sarcomatous, the whole thickness of the muscle should, when possible, be excised for some distance from the growth, since the lymphatics run in the direction of the fibres, but the sheath forms a limit not early overstepped. Amputation of the limb may, however, be required.

Diseases of Sheaths of Tendons.

1. **Acute Simple Teno-Synovitis** often follows sprains and strains, and is most commonly seen in connection with the extensor muscles of the thumb. A puffy swelling in the course of the tendons is produced, painful on movement and perhaps tender to the touch, giving a characteristic fine crepitus whenever the parts are moved.

Treatment.—Immobilize the limb for a few days, and apply fomentations. As soon as the more acute symptoms have disappeared, massage is employed to hasten the absorption of the fluid; whilst active and passive movements are undertaken to prevent the formation of adhesions.

2. **Acute Suppurative Teno-Synovitis** may result from a punctured wound of the synovial sheath, or the inflammation may spread to it from neighbouring tissues. The thecal variety of whitlow (p. 253) is of this nature. Suppuration may extend both up and down the sheath, and unless promptly treated by incision, the tendon will slough, or may contract extensive adhesions to neighbouring parts; in either case considerable impairment of function is likely to follow. When the tendon survives, active and passive movements must be started very early if the formation of serious adhesions is to be prevented. The suppuration may affect neighbouring articulations, leading to their disorganization, especially in the case of the tendon sheaths around the wrist-joint.

3. **Chronic Simple Teno-Synovitis** is a common affection, characterized by a passive effusion into the tendon sheath of glairy synovia, somewhat resembling uncooked white of egg. An elastic fluctuating swelling forms in the course of a tendon, usually associated with creaking. In the more limited varieties it constitutes one form of ganglion. There is no pain or tenderness, but the affected part feels weak. **Treatment** consists in counter-irritation and pressure, as by Scott's dressing; failing this, the part may be freely incised, the synovia removed, and, if need be, the cavity washed out. In the more localized forms it may suffice to puncture the cyst-like swelling and squeeze out the contents, pressure being subsequently applied.

4. **Chronic Tuberculous Teno-Synovitis** is of two types. In one the sheath is lined by œdematous granulation tissue of some thickness, containing tuberculous foci, giving rise to a soft elastic swelling along the course of a tendon, which increases slowly in size, and is but slightly painful or tender. Suppuration may follow, and subjacent bones or joints be involved. **Treatment** consists in immobilizing the part, pressure, passive hyperæmia, and improvement of the general health. If a cure is not quickly established, a free incision should be made and the diseased tissue removed.

The other form of tuberculous disease consists in a passive effusion into the synovial space, the lining membrane of which becomes thickened by the deposit thereon of fibrinous material. This is often detached, and by the movements of the part the loose fragments of fibrin are moulded into various shapes. In tendon sheaths they are often elongated, and constitute the so-called *melon-seed bodies*; but when they occur in joints, they remain somewhat flattened, whilst in bursæ they approximate more to the spherical. On examination, they are found to be structureless, though sometimes laminated. When numerous, they give rise to a curious and characteristic form of crepitus. That they are of a tuberculous nature can be demonstrated by inoculation experiments; the bacilli contained therein are not, however, in a very active state, and the prognosis of this type is more favourable than of the former.

Treatment consists in immobilization and pressure (as by the application of Scott's dressing), together with the daily application of an elastic bandage, so as to induce hyperæmia. Failing this, the part should be opened, the effusion removed, including fibrin and melon-seed bodies, iodoform gently rubbed in, and the cavity closed, after filling it with glycerine and iodoform emulsion. Should the trouble recur, a free incision and removal of the diseased membrane may be required.

A **Ganglion** is the term given to a localized cyst-like swelling forming in connection with a tendon sheath or joint. It is most commonly met with at the back of the wrist, arising from the tendons of the radial extensors of the carpus, and those of the thumb or index-finger, but it sometimes occurs on the front of the wrist or in the foot (Fig. 146). It varies in size considerably, and contains a clear, transparent gelatinous or colloid substance. A rounded firm elastic swelling is produced, usually somewhat moveable, and neither painful nor tender at first, although some painful weakness of the part may be experienced as it increases in size. It is due to one of several causes: thus, it may result from a chronic localized teno-synovitis, or from a hernial protrusion of the synovial membrane through an opening in the tendon sheath. Others seem to originate in a colloid degeneration of the cells lining the synovial space; whilst certainly some few arise in connection with subjacent articulations, in the same way as a Baker's cyst. Little difficulty arises in the diagnosis, although, when situated deeply and closely attached to a bone, they have been mistaken for exostoses. **Treatment.**—A ganglion may often be ruptured by manipulation and pressure with the thumbs, or by a forcible blow with a book, but it is apt to fill again. Failing this, a rapid cure is usually obtained by an aseptic puncture of the cavity, and the subsequent application of firm pressure. In some cases it may be advisable to lay the part open and remove the cyst wall as completely as possible; such treat-

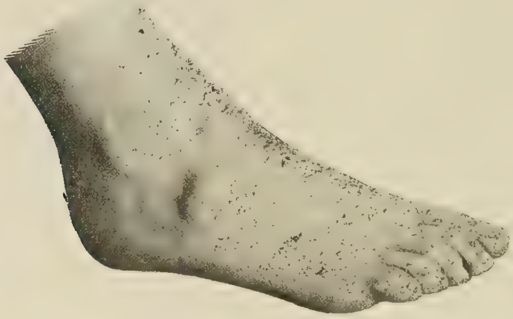

FIG. 146.—GANGLION OF EXTENSOR TENDON OF FOOT.

ment requires absolute asepsis, since, if infection occurs, most serious consequences may ensue.

A **Compound Palmar Ganglion** consists in a tuberculous affection of the common synovial membrane surrounding the flexor tendons of the wrist, the cavity being distended in the early stage with a glairy fluid, usually containing many melon-seed bodies, and perhaps later on with pus. In the early stages all that is noted is a fulness about the front of the wrist and palm, the normal hollow being obliterated. Later on a more definite swelling is observed, and this is found to extend into the thenar eminence, due to the involvement of the tendon sheath of the flexor longus pollicis. The condition is painless at first, and there is but little interference with the mobility of the tendons; but in the later stages of repair the tendons may become matted together, and the movements of the fingers hampered; or if the disease ends in suppuration, the pain and disability become more marked. In all stages fluctuation can usually be detected above and below the annular ligament, being transmitted beneath it. In the **Treatment,** rest and pressure, as by Scott's dressing, together with induced hyperæmia and suitable constitutional remedies, may first be tried; and failing this, an incision is made both above and below the annular ligament, the cavity being well washed out, and all melon-seed bodies and fibrinous débris removed. The cavity is then filled with the glycerine and iodoform emulsion, some of which may be gently rubbed into the pockets of the wound; both incisions are firmly sutured, and a further period of rest maintained. Should the skin become thin and undermined, drainage may be required, and even in a few cases division of the annular ligament, in order to deal effectively with the trouble by the sharp spoon. The results in such cases are not very good, as the tendons get matted together and adherent to the skin, and the movement of the fingers is thereby hampered.

Operations on Tendons.

1. By **Tenotomy** is meant the division of a tendon through an open or subcutaneous wound with the object either of remedying some deformity, such as talipes or torticollis, or of assisting in the reduction of some displacement, as in setting a fracture. It is accomplished in two ways, viz., by subcutaneous or open incision. The **subcutaneous** method is made use of where there is little likelihood of injuring important structures. The strictest attention to asepsis is desirable, since the characters of the wound, viz., a puncture, and the entire absence of drainage, are most favourable to the development of organisms, if entrance is once given to them. Moreover, the synovial tendon sheath is often, though undesignedly, wounded, and infection spreads rapidly along such a structure, and gives rise to serious consequences. The operation consists in inserting a sharp-pointed tenotome through the skin down to the tendon. This is then withdrawn, and a blunt-pointed knife passed along the

track thus made, either superficial to or beneath the tendon. The cutting edge is turned towards it, and the tendon divided by a sawing or rocking movement, whilst the structure is put on the stretch. It is undesirable to operate through the synovial sheath, since even if the wound remains aseptic, the tendon often retracts more than is desirable, and in healing gains adhesions to the sheath which considerably limit the subsequent freedom of movement of the part. Opinions vary as to whether it is better to pass the knife above or below the tendon; in the former method there is no likelihood of making an unduly large wound in the skin, and there is less risk of dividing the *lax* subjacent structures if the knife is turned towards them. On the other hand, if the knife is at once passed beneath the tendon, and any subjacent structures are by mistake included, their division is a matter of certainty. Where, however, there is any risk of dividing important structures, such as the external popliteal nerve in tenotomy of the biceps cruris, it is wiser to adopt the **open method.** In this an incision about 1 inch in length is made over the tendon, which can thereby be exposed, lifted on an aneurism needle, and severed without danger. There is no hæmorrhage worth mentioning, and the wound is closed by suture, dressed antiseptically, and firmly bandaged to prevent extravasation. The malposition is at once corrected, and the part immobilized at the time, or in the course of forty-eight hours, in plaster of Paris. Passive movements may usually commence at the end of twelve to fourteen days, and gradually be increased in vigour, until active movements are allowed.

Tenotomy of the Tendo Achillis.—The foot is placed on its outer side, and the tendon relaxed by pointing the toes downwards. The tenotome is introduced at the inner margin of the tendon, about 1 inch above its insertion (Fig. 109, F), either superficial to or beneath it, and it is readily divided when the foot is dorsiflexed. If the surgeon cuts towards the skin, he must not divide the last few fibres too rapidly, otherwise a considerable external wound may be inflicted by the suddenly liberated knife.

The *Tibialis Anticus* is usually divided about 1 inch above its insertion, as it crosses the scaphoid (Fig. 111, C). There is here no synovial sheath, and the arteria dorsalis pedis is separated from it by the tendon of the extensor proprius hallucis. It is first relaxed so as to allow of the introduction from the outer side of the sharp-pointed tenotome beneath it; this is replaced by a blunt-ended instrument, and the section is accomplished when the foot is abducted.

The *Tibialis Posticus* is usually divided together with the flexor longus digitorum just above the inner malleolus, at a spot about a finger's breadth from the tip of that process in an infant, and about 1½ inches from it in an adult (Fig. 109, E). A small tubercle can usually be felt here, and the section is made just above. The knife is inserted between the tibia and the tendon, and if correctly placed, remains fixed without the support of the hand, being grasped between the tendon and the bone. The blunt-ended tenotome is then introduced, and the edge being turned towards the tendon, the latter structure is divided when the foot is dorsiflexed. The posterior tibial vessels may be wounded, but a little well-adjusted pressure will suffice to prevent any serious consequences.

The *Peronei* tendons are divided just above the base of the outer malleolus, at a spot where the synovial sheath is usually absent (Fig. 110, D). The tenotome is inserted close to the fibula, between the tendons and the bone.

The *Biceps Cruris* tendon is best divided by an open operation, on account of the close propinquity of the external popliteal nerve, which has often been wounded in the subcutaneous operation. An incision is made in the direction of the tendon just above its insertion into the fibula. It is then lifted upon an aneurism needle and divided; muscular fibres will probably be found quite close to its lower end.

The *Semi-membranosus* and the *Semi-tendinosus* tendons are dealt with just above the knee-joint, and the subcutaneous operation may be conveniently adopted when they are prominent and tense. For division of the *Sterno-mastoid*, see p. 433.

2. **Lengthening a Tendon** is sometimes required, in order to overcome the deformity which results from loss of substance or contraction, where simple tenotomy does not seem desirable. It may be possible to utilize the method suggested on p. 416 for the union of a tendon where there has been loss of substance, viz., by bridging the interval by a flap turned down from one or both ends. Perhaps a more efficient method is the so-called Z-operation (Fig. 147). The tendon is split longitudinally (*bc*) into two halves, which are separated one from the other by cross cuts made on opposite sides, one at each end (*ab* and *cd*). The two flaps are then drawn apart for a distance corresponding to the increase in length required, and sutured together; the resulting bond of union will be as represented in Fig. 148.

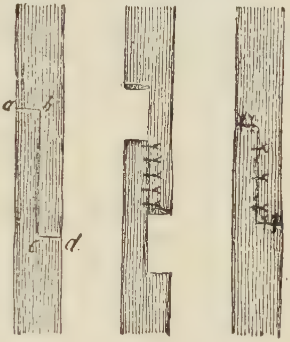

FIG. 147. FIG. 148. FIG. 149.

Z-OPERATION FOR LENGTHENING OR SHORTENING OF TENDONS.

In Fig. 147 the method of dividing the tendon is shown. In Fig. 148 the flaps are slipped downwards, one on the other, so as to lengthen the tendon. In Fig. 149 equal portions have been cut away from each half and the remainders sutured, so as to shorten it.

3. **Shortening a Tendon** is undertaken in some forms of paralytic talipes. The Z-method may also be employed here, the two halves, after they have been separated, being shortened to the required amount, and then stitched together (Fig. 149). This operation will

probably give a more solid bond of union than where a transverse or an oblique section is removed; in such the sutures are much more likely to cut out.

4. **Tenoplasty** is the term applied to any plastic operation on tendons with a view (1) to transfer the action of a healthy and strong muscle to the tendons of a weakened or paralyzed group, so as to limit the deformity or disability caused thereby; or (2) to displace the line of action of a muscle so as to counteract or obviate some deformity. Clearly, this operation finds its greatest use in paralytic affections such as talipes. It is essential to study carefully the peculiar features of each case where such a procedure is considered desirable, especially as to the electrical reaction and power of all the muscles involved and the relative importance of each possible movement. Thus, in the foot plantar-flexion is of more value to the patient than dorsi-flexion, and the latter is more useful than either adduction or abduction, whilst of the two last-mentioned movements adduction is more important than abduction. Hence, although it would be mechanically correct to transplant a healthy abductor, such as the peroneus longus, into a paralyzed plantar flexor, such as the tendo Achillis, so as to improve plantar-flexion at the expense of abduction, it would be unwise to reverse the proceeding. It is desirable that, wherever possible, the reinforcing tendon should be derived from a synergic and not from an opposing group, although with careful education muscles of opposing function may be utilized.

Two methods of tenoplasty are available: (1) *Tendon Implantation* consists in suturing the whole or part of the proximal end of the tendon of a healthy muscle to the distal end of the divided tendon of a paralyzed muscle, and for choice the latter should be divided as near its insertion as possible. The incision should be longitudinal, or a suitable flap may be raised. The actual method of union of the tendons varies with circumstances, but the best results have been obtained by threading the healthy tendon through a slit in the recipient, and then suturing them firmly together. Direct end-to-end suture of two tendons is less satisfactory. Occasionally merely a slip from the stronger tendon is employed, which is attached to the weaker one so as to fortify the latter without destroying the power of either. (2) By *Tendon Transplantation* is meant the total detachment of a tendon from its point of insertion with or without the periosteum or bone to which it is attached, and its transference and fixation to the point of insertion of the tendon of a paralyzed muscle, or to some spot where it can act more advantageously. It is fixed either by sutures to the periosteum, or by metal staples, or by drilling a hole through the bone and threading the tendon through it.

The greatest care must be taken with the technique of these operations, so as to ensure complete asepsis and perfect hæmostasis. Tendon sheaths must be closed by the finest catgut or silk sutures. Deformities should be corrected before the tendons are united, so as to ensure accurate length of the new structure. The after-treatment is in the first place directed to the avoidance of undue tension on the bond of union for fear that it may stretch. The parts should be kept in an over-corrected position for six weeks by splints or plaster of Paris. Subsequently a supporting instrument must be worn for six months, and the affected muscles are treated by massage, electricity, and educative exercises.

Diseases of Bursæ.

Bursæ exist as normal structures in many parts of the body exposed to pressure, their object being to diminish friction and permit of a gliding movement. Similar cavities, known as abnormal or **Adventitious Bursæ,** are developed in regions where exceptional pressure is brought to bear on some prominent structure; they consist of a fibrous wall lined by a serous membrane, contain a small quantity of serum, and are formed either by dilatation of lymphatic spaces, or as a result of a localized effusion into the tissues. Examples of this are met with in men following special occupations—*e.g.*, over the vertebra prominens of Covent Garden porters, and then known as a 'hummy'; Billingsgate fish-carriers occasionally have bursæ under the centre of the scalp; and deal-runners often present one on the upper part of the shoulder. They occur over bony prominences arising from malformation or displacement—*e.g.*, over the cuboid in talipes equino-varus, and over exostoses; whilst the false joint or pseudarthrosis which occurs in unreduced dislocations or ununited fractures is of a similar nature.

Wounds of bursæ may be caused by penetrating injuries, or sometimes by the skin over them splitting, as, *e.g.*, in a fall on the point of the olecranon. The escape of bursal fluid which results often prevents healing, and then it will be necessary either to excise the bursa, or to open it freely, so that it can be packed and allowed to heal from the bottom.

Subcutaneous injuries are followed by hæmorrhage constituting a hæmatoma, which may suppurate or become absorbed; in the latter case adhesions will often occur, and even polypoid fringes from the organization of the blood-clot. Treatment consists in keeping the part at rest, unless suppuration is threatening, and then an incision must be made. It is always well to make certain that no fracture is present beneath a hæmatoma of the olecranon or patellar bursæ.

The following are the morbid conditions which arise in adventitious as well as normal bursæ:

1. **Acute Simple Bursitis** results from moderate injury or prolonged irritation, especially in gouty or rheumatic individuals. The part becomes swollen, painful, and tender, and if superficial the skin over it may be hyperæmic. Effusion into the cavity quickly occurs, and is sometimes mixed with blood. Lymph is deposited on the serous surface, and in many cases results in the formation

of adhesions, and possibly obliteration of the cavity. **Treatment** consists in keeping the part at rest, and applying fomentations. If the effusion persists, aspiration, or removal with trocar and cannula under strict asepsis, may be employed, or even the whole cavity excised.

2. **Acute Suppurative Bursitis** arises from infection occurring either from without or within; it not uncommonly follows a subcutaneous injury of a chronically inflamed bursa, leading to its distension with blood. The pus, formed at first within the bursa, may travel directly to the surface, or, bursting through the capsule, is diffused through the tissues. Where this occurs, the characteristic features suggesting a bursal origin of the abscess may be masked. Thus, in suppuration of the bursa patellæ, the pus often finds its way to the lateral aspects of the limb, allowing the patella to be distinctly felt through the skin; the case might then be mistaken for suppuration within the knee-joint, but is easily distinguished by the absence of the more acute arthritic symptoms. Implication of subjacent bones and joints sometimes occurs; thus, the patella or olecranon may become carious, or necrose. The **Treatment** of suppurative bursitis resolves itself into an early free incision, and drainage.

3. **Chronic Bursitis with Effusion** is, perhaps, the most common pathological condition met with in connection with bursæ. The cavity becomes distended with a serous effusion of varying amount, giving rise to a fluctuating tumour. The walls differ in thickness according to circumstances; if the condition is one of long standing with frequent recurrences, the bursal wall is usually reticulated and dense, and adhesions, papilliform processes, or fibrous cords are often produced. Subacute exacerbations are frequently grafted on the more chronic variety. **Treatment** consists in rest and counter-irritation, as by blistering or iodine paint, and if this fails, the bursa should be dissected out. When the bursa communicates with a joint, such as that under the semi-membranosus tendon, the neck must be isolated, and its communication with the joint shut off by ligature.

4. **Chronic Fibroid Bursitis.**—In this variety the walls of the bursa are much thickened, as a result of prolonged irritation, constituting a hard fibroid tumour, in the centre of which is a small cavity. Possibly a syphilitic element is present in this condition. The only **Treatment** is complete removal.

5. **Chronic Tuberculous Bursitis** usually occurs in the form of a fibrinous deposit on the inner wall, together with effusion and the presence of loose fibrinous bodies. Less frequently the lining membrane is transformed into granulation tissue of a tuberculous type, perhaps leading to the formation of a chronic abscess. Either condition may be secondary to a tuberculous arthritis, or may give rise to it, when the bursa communicates with a joint. If total removal is impracticable, **Treatment** consists in laying the part freely open, scraping away all tuberculous tissue, and packing the cavity

with gauze impregnated with iodoform. Sometimes it is possible to fill the cavity with sterilized iodoform emulsion and close it entirely.

6. **Syphilitic Changes** may also occur in bursæ, in the shape either of a symmetrical bursitis in the early stages, or later on as a gummatous peri-synovial development.

7. Occasionally **Gouty Deposits** are observed in the walls of bursæ, constituting tophi, the irritation of which may predispose to abscess formation, pus mixed with urate of soda crystals being discharged. The bursa over the olecranon is said to be most frequently affected in this way.

Special Bursæ.

The *bursa patellæ* (Fig. 150), which lies over the lower half of the bone and not over its centre, is very liable, from its exposed situation, to injury or any of the above-mentioned varieties of bursitis. In its simplest form it constitutes the condition known as 'housemaid's knee,' and is due to kneeling Caries of the patella may follow acute suppuration, and the more chronic varieties may lead to osteoplastic periostitis. The knee-joint itself usually escapes.

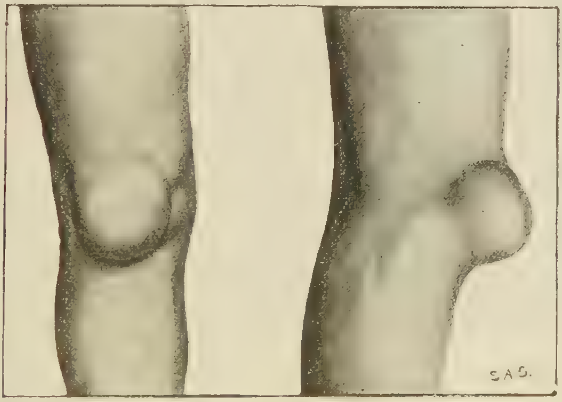

FIG. 150.—ENLARGED BURSA PATELLÆ. (FROM A PHOTOGRAPH.)

The bursa beneath the ligamentum patellæ, between it and the head of the tibia, when distended with fluid, gives rise to a fluctuating swelling felt on either side of the tendon, more especially when the limb is extended; when the leg is flexed, the swelling diminishes. Chronic enlargement of this bursa may push the ligamenta alaria backward into the joint, so that they are nipped between the bones whenever the patient attempts to stand with the leg extended; the pain thereby induced is somewhat similar to that caused by a displaced semilunar cartilage, or by a loose foreign body in the joint. The presence of the enlarged bursa, together with the inability to stand with a straight leg, should suffice to make the diagnosis clear.

The *bursæ in the popliteal space* are often enlarged, especially that between the inner head of the gastrocnemius and the semi-membranosus (Fig. 151), leading to a rounded fluctuating swelling, sharply limited on its outer aspect, and more fixed and less defined towards the inner. The sensation imparted to the fingers varies according to the position of the limb, the swelling being *tense in extension and flaccid in flexion*, as occurs in most of these peri-articular bursæ. Owing to the proximity of the popliteal vessels, pulsation is occasionally detected, but is not expansile in character. Enlargement of this bursa is often secondary to an articular lesion, especially tuberculous disease or osteo-arthritis, and before undertaking treatment the condition of the joint should be ascertained. If the joint is healthy, the bursa may be removed by dissection, the pedicle being closed by ligature or suture.

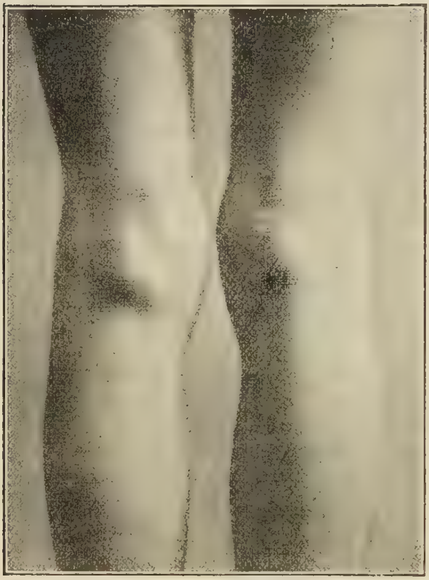

FIG 151.—ENLARGED SEMI-MEMBRANOSUS BURSÆ IN BOTH LEGS OF A BOY.

The *bursa beneath the insertion of the semi-tendinosus and gracilis* is sometimes inflamed, and is very liable to cause osteoplastic periostitis of the subjacent inner surface of the tibia.

The *bursa beneath the tendo Achillis*, if enlarged, presents a fluctuating swelling on either side of that structure, somewhat simulating disease of the ankle-joint, but necessarily limited to the posterior aspect of the joint. Primary tuberculous disease is sometimes present.

Distension of the *bursa beneath the psoas tendon* gives rise to a fluid swelling which usually projects anteriorly, presenting either on the outer or inner side of Scarpa's triangle. If painful, it necessitates flexion of the thigh, and thus leads to symptoms resembling those of hip-joint disease or of a psoas abscess. It must not be forgotten that this bursa often communicates with the joint.

The *gluteal* bursa, situated between the insertion of the gluteus maximus and the great trochanter, is not uncommonly the seat of tuberculous disease. It presents as a rounded swelling, obliterating the hollow behind the trochanter, and in its more acute manifestations may be accompanied by abduction and eversion of the limb, in order to relax as far as possible the gluteus. It may thereby somewhat resemble the earlier stages of hip disease, but is recognised by the absence of flexion, and by the fact that passive movements, including even the so-called test-movement for hip disease, can be undertaken with but little or no pain. Should suppuration occur, the pus may burrow widely beneath the gluteus. Treatment consists of complete excision, if possible, or incision with scraping and disinfecting the interior, and allowing it to heal from the bottom. Necessarily part of the insertion of the gluteus maximus will require division, and must be subsequently sutured.

The *bursa over the tuber ischii*, if inflamed, gives rise to the condition known as ' weaver's bottom '; it causes great discomfort in sitting, and is often solid and symmetrical. If troublesome, it should be removed.

Enlargement of the *bursa over the olecranon* constitutes the condition known as ' miner's elbow '; suppuration within it is not uncommon, leading to necrosis of the underlying bone; the elbow-joint is but rarely affected.

The large multilocular *subdeltoid bursa* is occasionally enlarged; it leads to prominence of the deltoid, and expansion of the shoulder. (For diagnosis from effusion into the shoulder-joint, see Chapter XXIII.)

CHAPTER XIX.

THE SURGERY OF DEFORMITIES.

It is only possible in a text-book of this character to deal with a few of the more notable defects.

Torticollis.

Torticollis, or wry-neck, is a deformity produced primarily by contraction of the sterno-mastoid muscle, although in old-standing cases the trapezius, splenii, scaleni, and other deep muscles of the neck, as well as the deep fascia, are affected. It is characterized by the affected side of the head being drawn down towards the shoulder, whilst the face is turned towards the sound side (Fig. 152).

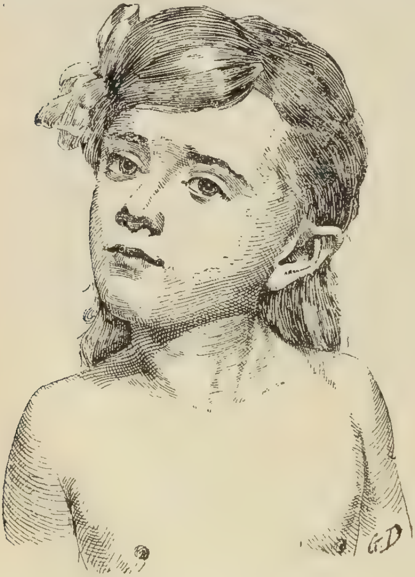
Fig. 152.—Chronic Torticollis. (From a Photograph.)

The left sterno-mastoid is contracted, and the corresponding half of the face atrophic.

Several different types are described, in particular the acute or rheumatic, the chronic, which is usually due to cicatricial changes in the muscle, and the spasmodic.

1. The **Acute** or **Rheumatic** variety is usually the result of exposure to cold or to sitting in a draught; it comes on suddenly, and is extremely painful, and the muscle or muscles affected are tender to the touch. The possibility of mistaking it for other inflammatory affections, such as acute lymphadenitis or cellulitis, must not be overlooked; in them the neck is often fixed so as to protect the inflamed structures. **Treatment** must be general as well as local; aspirin

may be given to relieve pain, or salicylates to counteract the rheumatic poison, whilst a dose of calomel or castor oil is always beneficial. Local fomentations should be applied in the early stages, and subsequently massage.

2. The **Chronic** form of torticollis is almost always due to cicatricial changes in the sterno-mastoid, which result in its intrinsic shortening. (*a*) It is occasionally *congenital*, and then it is due to malformation or malposition *in utero*, whereby the muscle is imperfectly developed. (*b*) Most commonly it follows the *congenital induration* of the muscle (*q.v.*), due to laceration of its fibres during birth; it is therefore to be looked on as a myositis fibrosa, somewhat akin to Volkmann's ischæmic contracture (p. 489). (*c*) At a later date contraction of the muscle may result from suppuration or gummatous formation within the sheath, but the deformity is then less marked.

Most commonly the sternal portion is contracted, whilst the clavicular half may be quite relaxed; the muscle usually stands out as a hard tense band, an excess of fibrous tissue being present, or the muscular substance almost entirely absent. The deep fascia always becomes secondarily contracted and shortened, and if the deformity has lasted long the posterior cervical muscles are similarly affected, whilst changes in the shape of the cervical vertebræ may also be induced, the bodies becoming wedge-shaped and thickest towards the convexity of the curve. A secondary compensatory curve is usually present in the dorsal region of the spine, so as to maintain the horizontal position of the eyes. In children the affected side of the head and face also becomes atrophic. The measurement from the external canthus to the angle of the mouth is smaller, the eyebrow is less arched, the nose somewhat flattened, and the cheek less full than on the sound side. These phenomena are probably due to imperfect vascular supply, resulting from the limited mobility.

The **Diagnosis** of a chronic torticollis is readily made from the fact that the sterno-mastoid muscle is evidently contracted and stands out as a tense band in the neck. It must not be confounded with cicatricial contraction of the skin of the neck following burns, or with the deformity and rigidity of the neck which result from a rheumatic inflammation of the deeper ligaments and muscles of the cervical spine (rheumatic spondylitis), or from tuberculous disease of the cervical vertebræ.

Treatment.—Massage and manipulation may be first tried, or even some form of mechanical apparatus directed towards stretching the contracted muscle (*vide infra*), but in the majority of cases tenotomy or myotomy will give a more satisfactory result, and is less tedious and troublesome.

Two methods of dividing the sterno-mastoid have been employed: (1) The *subcutaneous* operation is a somewhat undesirable proceeding, on account of the important structures placed immediately beneath it. There is but little danger or difficulty in dealing with the sternal head, a tenotome being passed down to it beneath the skin, and the incision made from before backwards; the tension to which it is exposed suffices to draw it well forwards out of harm's way. The clavicular portion, on the other hand, should always be divided through an open incision. (2) The *open* method is far preferable, as thereby all danger is obviated. The skin, about ½ inch above the clavicle, is incised across the muscle, its anterior and posterior borders are defined, and its fibres completely divided. Tense portions of the deep cervical fascia on its deep aspect may also be carefully cut across, keeping in view the importance of the underlying structures. The position of the head is then rectified, and fixed by plaster of Paris or some other suitable apparatus. A simple and satisfactory arrangement consists of a padded leather strap passed round the forehead and occiput, and another under the axillæ. A chain or elastic band is secured to the forehead strap above the mastoid process of the side which is not affected, and traction made by fixing it to the front of the lower belt on the opposite side of the body. Thus, if the left sterno-mastoid is contracted and has been divided, the chain is attached above over the right mastoid process and below over the front of the left axilla, traction being thus made in the direction of the weakened right sterno-mastoid muscle. In some cases more efficient support is necessary, and may be obtained by the use of Chance's back splint (p. 441), to the upper end of which arms are attached, bringing pressure to bear upon each side of the head in suitable directions. Where, however, osseous changes are present, the deformity may persist to a great extent, in spite of combined operative and mechanical treatment.

3. **Spasmodic** torticollis is a condition which occurs most frequently in women about thirty years of age, in whom there is often a family history of insanity or nervous diseases, such as epilepsy, etc. It is characterized by clonic spasms of the various muscles of the neck, especially the sterno-mastoid and trapezius, but the deep short rotator muscles are also affected in many cases. The head is continually being twisted and jerked into a position of torticollis, but other movements are often associated. The cause is some lesion of the nervous supply of the muscles, probably in most cases cortical. In a few instances irritation of peripheral nerves, as by inflamed glands, teeth, etc., may exert some temporary influence, but the true spasmodic wry-neck persists in spite of the removal or cure of such causes. The prognosis is always very unfavourable, since, even if the localized spasm is cured by appropriate operative treatment, other parts are likely to become affected.

Treatment in these cases must be of a hygienic and tonic character; peripheral sources of irritation must be removed, and careful investigation made to ascertain that all the functions of the body are satisfactorily performed. Intestinal toxæmia, disorders of menstruation, and any other possible causes of irritation, must be relieved. Local applications of electricity of various types may be employed, as also various hydro-therapeutic remedies. Where these have failed, the spinal accessory nerve may be exposed, and either stretched or excised (p. 386). Not unfrequently the spasms persist in spite of this, and then it may be well to divide the posterior cervical nerves, as they lie on the semi-spinalis colli (Keen). Should this fail, it may be justifiable to deal with the cortical centres.

Hysterical wry-neck is occasionally seen, and must be carefully differentiated from the above varieties. It may last for a varying period, but under suitable treatment disappears completely.

A **Cervical Rib** is a deformity of not uncommon occurrence, generally noticed about the age of puberty. It is usually bilateral, and arises most frequently from the anterior transverse process of the seventh cervical vertebra, but a similar outgrowth sometimes occurs from the sixth. It is composed mainly of cartilage at first, but as age advances it becomes osseous. It may be short and have a free end in the neck, but more frequently passes down to unite with the first rib near the scalene tubercle, or to gain attachment to the sternum; occasionally it consists of two portions, an upper and a lower, united together by a synchondrosis. No symptoms are produced until the mass by its growth encroaches on the subclavian artery and lower and inner cords of the brachial plexus. The vessel is pushed upwards and forwards, and becomes so prominent as at times to be mistaken for an aneurism; sometimes the pulse is impaired when the arms hang down, and this may even determine gangrene of the finger-tips. Nervous symptoms are referable to the first dorsal and eighth cervical nerve-roots, and appear in the form of neuralgia along the ulnar border of the fore-arm and little finger, or of paralysis mainly of the intrinsic muscles of the thumb. A cervical rib presents as a hard swelling above the clavicle, and can be readily recognised by radiography. Nothing should be done to it unless pressure symptoms are present, when removal may be required. An incision is made parallel to the anterior border of the lower portion of the trapezius; the nerves and vessels are separated from the mass of cartilage and drawn aside, and the growth carefully excised by gouge, chisel, or cutting pliers.

Deformities of the Spine.

Scoliosis.—By scoliosis is meant a lateral curvature of the spine accompanied by rotation of the vertebræ. Conditions are met with in which the spine becomes deflected laterally as an occasional result of Pott's disease, or in fractures; such, however, are not generally considered to be genuine scoliosis.

Ætiology.—The following are the chief causes of scoliosis: (1) It occurs very rarely as a congenital deformity, owing to malformation of the vertebræ. (2) It may commence in young children as a result of *rickets*, owing partly to the softened condition of the bones, partly to their irregular growth. It is probably often induced by the children being always carried on the same arm. The primary curve in this type is usually one directed towards the left in the dorsi-lumbar region. A similar change, due to the so-called 'adolescent rickets,' may also occur in children who are able to run about. (3) Any condition of asymmetry of the body may lead to what is known as *compensatory scoliosis*—*e.g.*, congenital shortness of one leg, unilateral dislocation of the hip, contractions of the knee- or hip-joint, genu valgum, falling in of the chest wall as a result of empyema, and even old-standing torticollis. If one leg is short (Fig. 153), the pelvis is tilted down on that side in order to bring the foot to the ground, producing a lumbar curve with the convexity towards that side, whilst a compensatory dorsal curve in the opposite direction is subsequently added in order to maintain the general axis of the body (A¹). If, however, the short leg is also persistently adducted, as in old hip disease (Fig. 154, B), the spine will be curved in the opposite direction in order to maintain the parallelism of the limbs (B¹). When due to empyema, a primary dorsal curvature is produced, with its convexity towards the sound side. In torticollis the cervical curve is primary, and a compensatory curve in the opposite direction in the dorsal region usually follows. (4) The most common type, however, is the *scoliosis of adolescents*, met with in young people about the age of puberty, or a little older, who are in a weak and asthenic condition, often as a result of rapid growth, combined possibly with improper or insufficient food, defective hygienic surroundings, or exposure to hard work, whereby undue muscular fatigue is induced. Young women of an anæmic type who suffer from amenorrhœa, and who as housemaids or factory hands have to undertake a good deal of lifting, are especially liable to this condition. It is due to a relaxed state of the ligaments and muscles, which have not developed *pari passu* with the weight and length of the skeleton; it is therefore not unfrequently associated with flat foot and genu valgum. Prolonged standing in a position of ease or rest, in which the weight is mainly carried on one

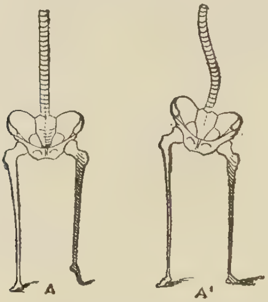

FIG. 153.—SCOLIOSIS DUE TO SHORTENING OF THE LEFT LEG.

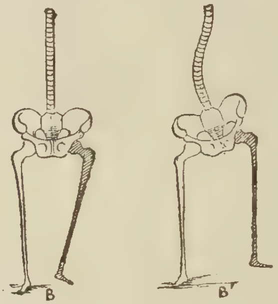

FIG. 154.—SCOLIOSIS DUE TO ADDUCTION OF THE LEFT HIP.

leg, may determine its occurrence, as also faulty positions occupied by children at school, owing to low desks and want of support to the feet.

The **Phenomena** vary considerably according to the character and extent of the lesion. Sometimes the whole spine is involved in one curve (*total* scoliosis); but more usually two curves are present, one primary, the other compensatory. It is by no means uncommon for this condition to be associated with kyphosis, but the absence of the latter, in what is sometimes termed the 'flat-backed' type, is no criterion of the slightness of the case. The most usual variety is that in which there is a double curve, with the dorsal convexity to the right and the lumbar to the left (Fig. 155). It will be desirable to describe this carefully, whilst for the opposite condition all that is necessary is to transpose the words 'right' and 'left,' or, as Hoffa has put it, one variety is the 'mirror picture' of the other.

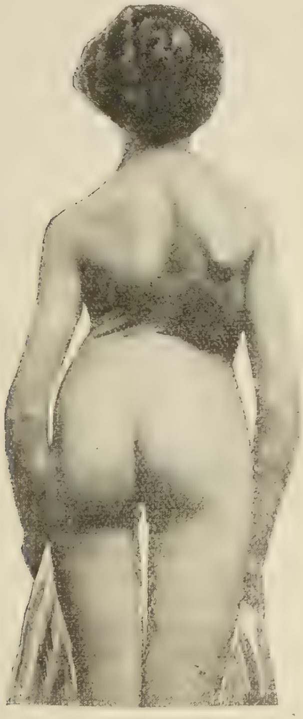

FIG. 155.—PHOTOGRAPH OF ORDINARY TYPE OF ADOLESCENT SCOLIOSIS.

The apparent asymmetry of the legs is in this case a photographic error; in reality they were both well developed.

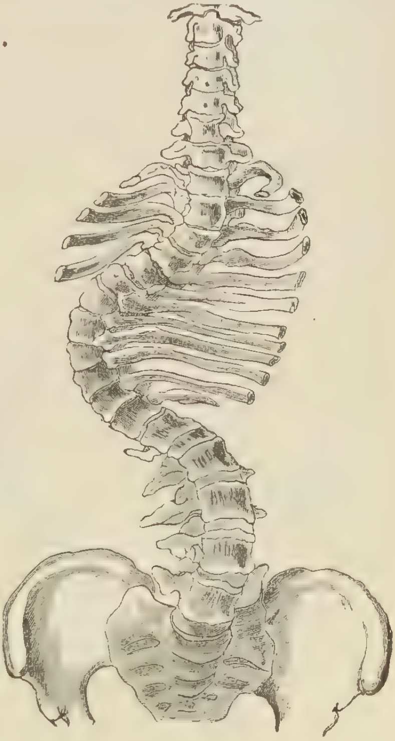

FIG. 156.—SPINE IN SCOLIOSIS SEEN FROM IN FRONT. (TILLMANNS.)

In addition to the lateral displacement, *the bodies of the vertebræ* (Fig. 156) are always *rotated* towards the convexity of the curves. This is probably a purely mechanical act, and due to the more firm support given to, and the interlocking of, the posterior parts of the vertebræ. As a result, the spinous processes are directed towards the concavity, and hence always indicate a smaller amount of distortion than really exists. Occasionally there may be some backward projection of the spines at the junction of the two curves.

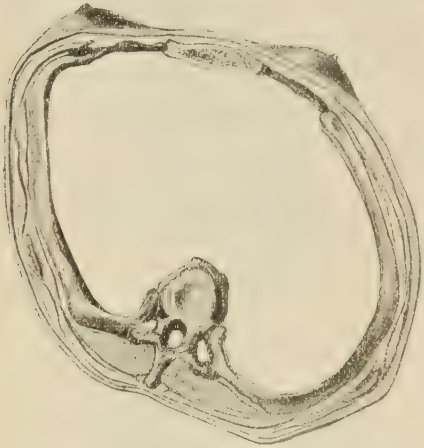
FIG. 157.—SECTION OF THORAX IN SCOLIOSIS. (AFTER HOLMES AND HULKE.)

The *thoracic walls* necessarily participate in the process, and the amount of thoracic deformity is perhaps the best measure of the degree of rotation of the vertebræ. The ribs on the right side become to some extent separated from one another, and project posteriorly on account of this rotation (Fig. 157); the amount of curvature at the angle is consequently increased, whilst the front of the chest on this side of the body becomes flattened. On the left side the ribs are huddled together, and the curve at the angle diminished, the ribs being thereby opened out; consequently, the thorax is flattened posteriorly on that side, but projects in front; the left breast may thus be rendered prominent. In fact, the thorax becomes more or less rhomboidal in shape. The sternum also is somewhat displaced towards the concavity, and twisted so that the anterior surface looks towards the right. The capacity of the thorax is not as a rule affected at first, but in the later stages it is considerably diminished, and the abdominal viscera may even be displaced. The *scapulæ* follow the thoracic wall, and hence the right shoulder is pushed upwards and outwards, and it is for this 'growing out of the shoulder' that the majority of cases come under observation. The effect on the *waist* varies with the situation and extent of the curves; if the dorsal and lumbar curves are nearly equal, then the true waist on the right side becomes more marked than usual, corresponding to the lumbar concavity, and in advanced cases a distinct sulcus may be present between the lower ribs and the crest of the ilium. On the left side the hip appears to project ('growing out'), owing to the deflection of the trunk towards the right side (Fig. 155), whilst the dorsal concavity higher up may simulate a false waist. The erector spinæ muscle stands out unduly on the left owing to the rotation of the vertebræ, whilst the transverse processes on this side may be unusually evident.

In the early stages the characteristic deformity disappears on extension of the trunk, as by hanging from a trapeze, or on bending forwards; but as it progresses, the spine becomes more and more fixed, and but little alteration is produced by suspension of the patient. In the worst cases, especially when associated with kyphosis, the deformity becomes so marked as to simulate the 'hump' formed in Pott's disease, and the patient's stature becomes dwarfed and stunted.

Subjective symptoms, such as neuralgic pain and weakness, are also present, but usually they are not very prominent features.

Anatomical Changes.—The structure of the spinal column is at first not manifestly altered, but as soon as the deformity becomes chronic, the individual vertebræ become mis-shapen. The bodies become wedge-like on section, being thicker on the convex than on the concave side. The *intervertebral discs* are similarly changed, whilst the *articular processes* are unduly pressed together on the concave side, and separated from one another on the convex. The transverse and spinous processes are also approximated to one another on the side of the concavity, and often curved. The *ligaments*, which in the early stages are relaxed, becomes secondarily shortened on the concave side, and may indeed disappear, the bodies of the vertebræ being ankylosed. The *muscles* accommodate themselves to the altered curves of the spine, and hence are contracted on the concave side and stretched on the convex.

It is most essential that a correct **Diagnosis** be made as soon as possible, since so much depends upon early treatment. A thorough examination should be made with the clothes stripped to below the waist, so that the whole back can be seen. The patient should be made to sit straight up on a stool or chair placed sideways, and the surgeon stands behind her. The general appearance is first noted, and then the spinous processes are marked out one after another with a spot of ink or with a flesh pencil. The shape of the thorax, the curvature of the ribs, and the position of the scapulæ, are also ascertained, and the length of the legs is measured. The patient is then made to stand, to hang from a bar, and to bend forwards, and the effects of these respective movements noted; by this means some idea can be obtained of the extent and nature of the deformity. There can be but little risk of mistaking it for Pott's disease, since the rigidity, deformity, and localized pain of the latter are so characteristic; in those cases of scoliosis, however, where there is a projection of the spinous processes backwards, a mistake might easily arise if only a careless examination were made.

The **Prognosis** necessarily varies with the stage which the affection has reached. In early days, before the deformity has become set, and when it disappears on extension of the spine, it is almost certain to be entirely cured, if suitable precautions are taken. Later on it can be improved to some extent, but in bad cases all that can be expected is to prevent it from getting worse.

In the **Treatment** of scoliosis, the cause of the trouble must not be overlooked, since in many cases the deformity may be remedied, or at any rate prevented from increasing, by attending to this. Thus, inequality in the length of the limbs necessitates the wearing of a high-heeled boot, whilst contractions of the knee- or hip-joints should, if possible, be corrected. In that variety which occurs in young people from constitutional or local debility, the general health must be improved by a visit to the seaside, or the administration of tonics such as iron and arsenic. Carefully-regulated rest and exercise must also be recommended, so as to improve the muscular tone of the back without unduly fatiguing the patient; for a similar reason massage and cold baths are beneficial. All errors of position must be corrected, and suitable desks, forms, and chairs utilized. In the slighter cases it often suffices to order the patient to rest in the supine position on an inclined board for an hour or two daily, the head being thus raised and the spine extended. Calisthenic movements and gymnastic exercises, especially on the horizontal bar and trapeze, constitute the most important element of treatment, which may be looked on as curative in early and moderate cases, and as palliative in the advanced stage. Of these exercises, the details of which vary with each patient, some are arranged so as to extend and render mobile the spine, and generally to improve the tone of the spinal muscles; others are devised so as to undo the abnormal curves present. Space forbids us describing them here, and we must refer readers to special text-books.

A spinal support is often useful, but should not be worn continuously, except in bad cases, as it renders the muscles of the back weak from disuse. All that is needed in the early stages is the support of a firm, carefully-fitted corset; but should the deformity increase, stronger steel instruments may be employed in which springs are incorporated, whereby it is hoped that correction of the curvature may be brought about. In the worst cases, where the deformity is irremediable, much can be done by a skilful mechanism to hide the deformity and prevent its increase.

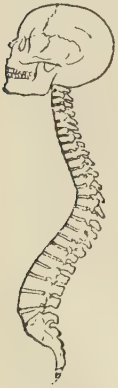
Fig. 158.—Kyphosis.

Kyphosis.—By this term is meant a condition of increased dorsal convexity of the back (Fig. 158), which is often associated with loss of the lumbar concavity, so that the whole spine is arched backwards. Occasionally, however, a marked lumbar lordosis is present as a compensatory condition.

The chief **varieties** of kyphosis are as follows:

1. Kyphosis from defective growth or habit. This may occur (*a*) in children under the age of four, resulting from rickets; (*b*) in adolescents up to the age of sixteen (round shoulders), from a continuous habit of stooping, as in reading or writing, especially in those suffering from myopia; (*c*) various forms of occupation, which involve the carrying of heavy weights, or stooping over work,

lead to its appearance in adults, as in porters and cobblers (Fig. 159); (*d*) in old men it results from senile atrophy.

2. Kyphosis from general diseases of the spine is a marked feature in spondylitis deformans, osteitis deformans, osteomalacia, hypertrophic osteo-arthropathy, and acromegaly. In the latter disease the condition is limited to the dorsal region.

3. Kyphosis from localized injury or disease of the spine is sometimes described, although it is more commonly known by the contradictory term 'angular curvature.' It results from fractures, Pott's disease, gumma, or cancer (*q.v.*).

Treatment is impossible in the majority of cases, but the round shoulders of young people come so commonly under observation that a little more notice of the condition is needed.

Round Shoulders occur most frequently in girls who have grown rapidly, and perhaps developed precociously. The condition is often due to defective habits of sitting and standing, especially at school, and may be induced by faulty desks and chairs, whilst other intrinsic conditions, such as myopia or adenoids, may also be primarily responsible. The spine becomes bent forwards in the cervico-dorsal region; at first the deformity can be voluntarily corrected, but not so later on.

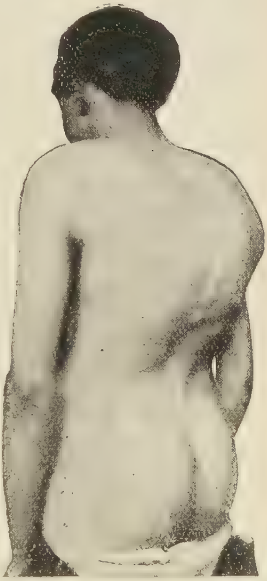
FIG. 159.—ACQUIRED OCCUPATION KYPHOSIS IN A YOUNG MAN, FROM EXCESSIVE WEIGHT-CARRYING.

Treatment.—In the first place the cause must be ascertained, and if possible, removed; in particular, chairs and desks must be arranged so as to ensure that the child sits in a good position, and does not stoop whilst writing, reading, or playing the piano. In particular, the back should be supported whilst reading, and the feet should not be allowed to dangle. The muscles of the back, especially the trapezii, the erectores spinæ, the rhomboidei, and the serrati, must be strengthened by massage, electricity, and exercises, the latter necessarily directed towards extension of the back. The girl should never be allowed to fatigue herself unduly, and must rest on her back two or three times a day for half an hour. At night she should lie on her back, without a bolster, and with a pillow beneath the curve. The general nutrition and health must also be attended to, and a course of suitable tonics prescribed. In bad cases where the deformity is marked and it is feared it may be progressive, a light support may be required; a Chance's splint* will do as well as any, but of course the exercises must be persisted in.

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* Many modifications of Chance's original splint have appeared, but the essential features of all are the presence of a metal pelvic band, from which

Lordosis (Fig. 160) is almost invariably a secondary or compensatory condition, and consists in an increased anterior curvature of the spine in the lumbar region. It is usually produced by continued flexion of the hip, whether due to congenital displacement, unreduced dislocation, malunited fracture, or to hip disease, and in such cases it is irremediable unless the malposition of the femur can be corrected.

It is seen as a temporary condition in pregnancy, and as a more persistent phenomenon in bad cases of uterine fibroids, owing to the increased weight of the uterus or its contents, necessitating backward displacement of the upper part of the spine in order to adjust correctly the centre of gravity of the body. The same may be noticed in persons with large, fat, and pendulous abdomens.

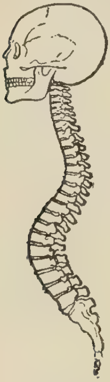
FIG. 160.—LORDOSIS.

It is occasionally present in progressive muscular atrophy where the lumbar and abdominal muscles are weakened, and usually in pseudo-hypertrophic paralysis from loss of power in the gastrocnemii and other muscles engaged in maintaining the erect posture.

Spondylo-listhesis is the term applied to a curious and somewhat uncommon deformity, in which the lumbar vertebræ slip forwards and downwards from the top of the sacrum. It arises from fracture of the articular processes of the lumbo-sacral synchondrosis, or from imperfect development of the laminæ or pedicles of the lowest lumbar vertebra, as a result of which the pressure of loads carried on the shoulders or the weight of a pregnant uterus brings about the displacement. In the latter instance the enforced lordosis aggravates this tendency. The effects produced are shortening of the stature, together with the formation of a marked hollow above the sacrum, whilst the lumbar vertebræ are unduly prominent anteriorly. The condition is accompanied by neuralgic pain and weakness. The only *treatment* is prolonged rest in the recumbent posture, and possibly the application of a leather jacket, moulded to the pelvis, and supplied with crutches, so as to carry part of the weight downwards from the axillæ to the pelvic support without utilizing the spine.

Deformities of the Upper Extremity.

In **Congenital Elevation of the Scapula** (Sprengel's Shoulder) the scapula may be normal in size or a little smaller than usual, but is situated above its proper position, and rotated so that its lower

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rises a single or double bar of malleable iron, fitted to the back, and capable of having its curve altered. Lateral supports spring from the central bars or bar, and straps to fix it in position are also provided.

angle is approximated to the middle line. The muscles attached to its upper border are prominent; in a few instances a cartilaginous or osseous band has replaced them, passing between the upper angle of the bone and the seventh cervical vertebra. The lower third of the trapezius is often defective, as also the serratus magnus. The disability, which is usually slight, depends on the condition of these muscles, but the affected arm is sometimes smaller than its fellow. A slight degree of scoliosis develops as a compensatory phenomenon. The only active *treatment* consists in dealing with the affected muscles by removing the cartilaginous or osseous band; otherwise massage and exercises are required.

A **Winged Scapula** is a condition characterized by projection backwards of the vertebral border and lower angle of that bone when the arm is thrust forwards (Fig. 161). It is due to paralysis of the serratus magnus and rhomboids, resulting from neuritis or trauma of the roots of the fifth and sixth cervical nerves, or of the special branches to these muscles; the nerve-roots are not unfrequently tender on pressure. **Treatment** consists in massage and faradism, whilst, if persistent, a suitable appliance may correct the deformity.

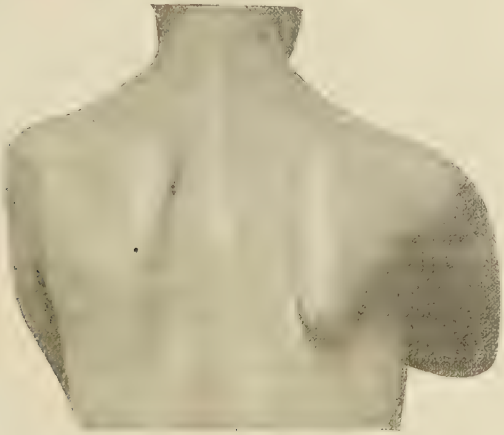

FIG. 161.—WINGED SCAPULA.

Various types of **Club-hand** occur, in which the hand is deflected to one or the other side, or is hyper-extended or flexed. Perhaps the most frequent cause is a *congenital absence of the radius*, under which circumstances the hand is radially abducted to a marked degree, the ulna is shortened and curved, and its lower epiphysis expanded, so as to articulate with the carpal bones. Where the bones are normal, the hand is usually flexed and adducted towards the ulnar side. In any of these deformities radiography should be employed, so as to ascertain the exact relation of the bones to each other.

Congenital Deformities of the Finger are much more common, and the account here given of such defects of the upper extremity applies with equal force to those which occur in the lower. The following varieties may be alluded to:

Polydactylism consists in the presence of supernumerary fingers and toes. There may be from one to seven additional digits, and the condition is usually symmetrical. One case is on record with twelve and thirteen fingers on the hands, and twelve toes on each foot. The accessory digits are often stunted, and smaller in size than the normal, but may be of average dimensions. Usually they are separated from the true digits, but now and then may be blended with them. The correct number of metacarpal or metatarsal bones may be present, or they also may be multiplied. In one of our cases there were six digits and six metatarsal bones; but the last two digits were supported by an accessory metatarsal apparently springing from the outer side of the fourth. The condition is frequently inherited. The **Treatment** consists in removing the supernumerary digits, if useless, obtrusive, or troublesome. Sometimes the patients are proud of their abnormality, and refuse to part with it.

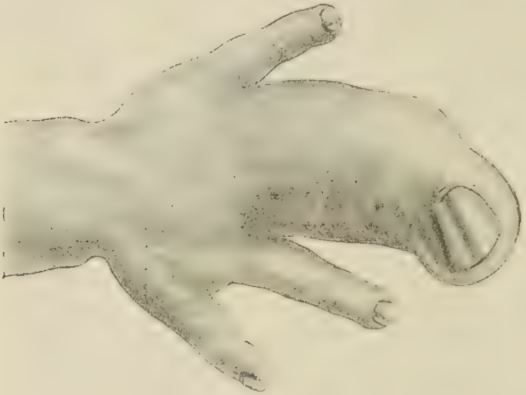

FIG. 162.—MACRODACTYLY AND SYNDACTYLY.

In this case a child, aged two and a half years, had the ring and middle fingers united laterally into a large mass which projected far beyond the others. The middle finger was normal in size, the ring finger was hypertrophic. A fruitless attempt was made to save the middle finger, but both had finally to be amputated.

Ectrodactylism, or the absence of one or more of the digits, is occasionally seen, as also partial arrests of development of fingers or toes, or intra-uterine amputation at a higher level.

Macrodactyly (Fig. 162) consists in a congenital overgrowth of one or more fingers or toes. The structures are perfectly normal in character, and merely gigantic in size for the age of the individual.

Amputation or excision may be needed in these cases, as the deformed parts grow out of all proportion to the neighbouring tissues. Thus, an infant with enormous overgrowth of the second toe of the right foot was successfully treated by excision of the digit, together with a V-shaped portion of the foot, which was by this means reduced to normal shape and size.

Syndactylism, or webbed fingers, is a condition in which two or more fingers are joined together laterally, either by a thin web consisting mainly of skin, or by a thick fleshy bond of union. In the foot no *treatment* is required, but in the hand the fingers must be separated. If there is merely a thin web, this may be divided by scissors; but to prevent its reformation from above downwards, as healing proceeds, a flap of skin must be transplanted into the angle between the fingers, or an opening in the base of the web may be made and maintained, and the edges allowed to cicatrize before the web itself is divided. Where the union, however, is thick and fleshy, a more extensive operation is needed. Two flaps of skin as long as the web, and half the width of a finger, are respectively raised from the dorsal aspect of one finger (Fig. 163, A) and from the palmar aspect of the other (B), in such a manner that, after the web has been divided, the denuded surfaces can be covered by wrapping the flaps round the lateral aspects of the fingers and suturing them in position. An additional flap of skin must also be fixed in the angle between the separated digits.

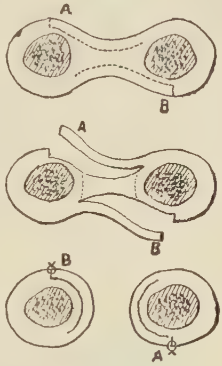

Fig. 163.—Operation for Syndactyly.

Congenital Contraction of the Fingers is not a very rare deformity, being frequently inherited; it is usually limited to the little finger and may be associated with congenital hammer-toe. It is due to contraction of the *central* prolongation of the palmar fascia in the finger, whereas Dupuytren's contraçtion involves the palmar fascia itself and its *lateral* prolongations into the fingers. Moreover, in the congenital variety the first phalanx is hyper-extended, and the second and third flexed, whereas in the acquired form the first and second phalanges are flexed and the third is hyper-extended. **Treatment.**—It often suffices to use massage and apply a splint, but in bad cases division of the fascial bands may be needed.

Acquired Deformities of the Hand.—After burns the hands may be contracted into a useless mass in which the fingers are drawn into the palm and united by cicatricial tissue to the palmar structures, so that all treatment is hopeless.

Spring-, Jerk-, or Snap-finger is a condition in which, when the patient attempts to open his hand, one finger or the thumb remains flexed, and on extending it with the other hand it flies open with a jerk or snap. Slight tenderness is usually felt near the metacarpo-phalangeal articulation, and the cause of the trouble is some obstruction to the free working of the long tendons under the transverse ligament at the root of the fingers, or between the sesamoid bones of the thumb. In a few cases a ganglion has been present here, but in most instances the condition is due to an increase in size of the sesamoid bone which radiography has taught us occurs constantly in this situation. **Treatment** consists in an aseptic incision to remove the cause of the obstruction.

A **Mallet Finger** is one in which the terminal phalanx is maintained in a state of flexion owing to some damage to the extensor aponeurosis. Its **treatment** in the early stage has been already alluded to (p. 417); should the deformity be persistent, an incision is made on the posterior aspect of the finger, and the weak tendon isolated and stitched down in such a way as to give it a better attachment to the bone.

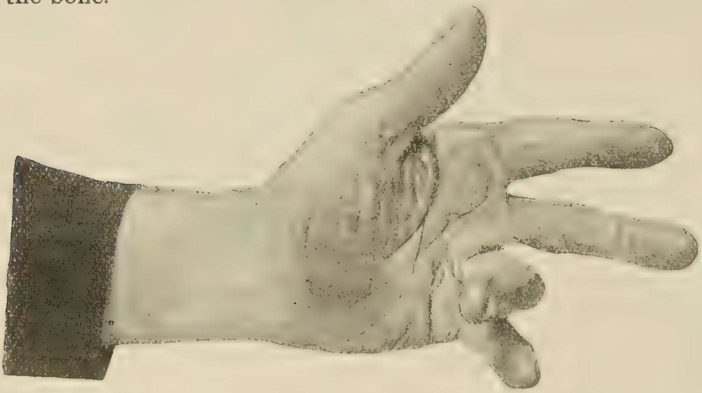

FIG. 164.—DUPUYTREN'S CONTRACTION.

Contraction of the Palmar Fascia (Dupuytren's Contraction).—This condition is usually met with in middle-aged individuals of a gouty temperament, more often in men than women, and not unfrequently on both sides of the body. It may or may not be associated with direct irritation of the palm, as by leaning much on a round-headed cane, or from the constant use of some instrument, such as an awl, whilst heredity is an important causative factor. Pathologically, it is due to a chronic overgrowth and contraction of the fascia, inflammatory in nature, and cirrhotic or sclerosing in type. It commences as an indurated subcutaneous nodule in the palm of the hand, about the situation of the most marked transverse crease, and affects most commonly the ring and little fingers first, the other fingers and thumb being less often involved. The induration spreads slowly both up and down the fascial bands into the fingers, which, as it increases, are gradually drawn into the palm and fixed, so that extension becomes impossible (Fig. 164). The flexion is limited to the first and second phalanges, the third remaining extended, and, indeed, sometimes assuming a position of hyper-extension, owing to the injudicious application of a splint. The skin over the indurated masses is sooner or later incorporated with them, and may become dimpled or creased by the traction of the subcutaneous connecting bands.

The **Diagnosis** of Dupuytren's contraction is exceedingly easy, the only condition for which it is likely to be mistaken being the congenital contraction already noted, and the flexion of the finger due to contraction, division, or destruction of the long tendons. In the latter case there is, as a rule, no palmar induration, but there will be a history of injury or inflammation, and some scarring (see p. 417).

The only satisfactory **Treatment** is by operation, and the following methods are those which are most successful: (*a*) Adams' subcutaneous section of the fascia and its prolongations consists in dividing the indurated bands by a tenotome in several places, where they can be felt tense. One puncture and division must be made in the centre of the palm; a second divides the same band as near the finger as possible, whilst the third and fourth deal with the lateral prolongations at the sides of the finger; if other bands still exist, they are treated similarly, the tenotome, if possible, in all cases being inserted between the skin and the fascia. The improvement thus produced must be maintained and increased by the subsequent use of suitable apparatus and passive movements, but the final results are not very satisfactory. (*b*) Kocher's method consists in the total extirpation of the thickened bands and their prolongations through longitudinal incisions. The fingers are at once straightened, and subsequent contraction is prevented by mechanical appliances. Many excellent and lasting cures have resulted from the latter operation.

Deformities of the Lower Extremity.

Congenital Dislocation of the Hip is by no means rare, although its causation is still quite uncertain. It is frequently bilateral, though more commonly unilateral; it occurs much more often in girls than in boys. It may pass unnoticed until the child begins to walk, and then the characteristic signs become evident. The limb is shortened and flexed on the pelvis, owing to the traction of the iliopsoas muscle, resulting in a considerable amount of lordosis (Fig. 166), whilst scoliosis is well marked in one-sided cases. Since the head of the femur is displaced from the middle line, a gap is usually noticed between the thighs close to the perineum. Considerable adduction of the lower end of the femur is present (Fig. 165), and in bilateral cases a scissor-leg deformity may ensue. The patient's gait is of a curious waddling character, which becomes very marked if one side alone is affected. Since the head of the bone is only maintained in position by its ligamentous and muscular attachments, it can often be drawn down at first, and the leg thus lengthened to the extent of an inch or two; moreover, it is often easy to reduce the displacement and put the head of the bone in the acetabulum in children that have not walked much. At a subsequent date strains to the limb are almost entirely borne by the ligamentous tissues, and hence attacks of synovitis are common.

The **Pathological Anatomy** varies considerably according to whether or not the child has walked. At *birth* the head and neck are sometimes nearly normal in shape, and located near the acetabulum; generally, however, the head is rather small and perhaps flattened at the spot where it rests against the innominate bone, and the neck is short and stunted. The ligamentum teres is long, thin, and band-like. The acetabulum is smaller and more shallow than usual; it can often receive the head of the bone, though it cannot retain it. The capsule is large and roomy. *After the child has walked,* sundry modifications make themselves evident. The head of the bone becomes more and more displaced, so that finally it may lie well above the acetabulum on the dorsum ilii (Fig. 167). The capsule becomes

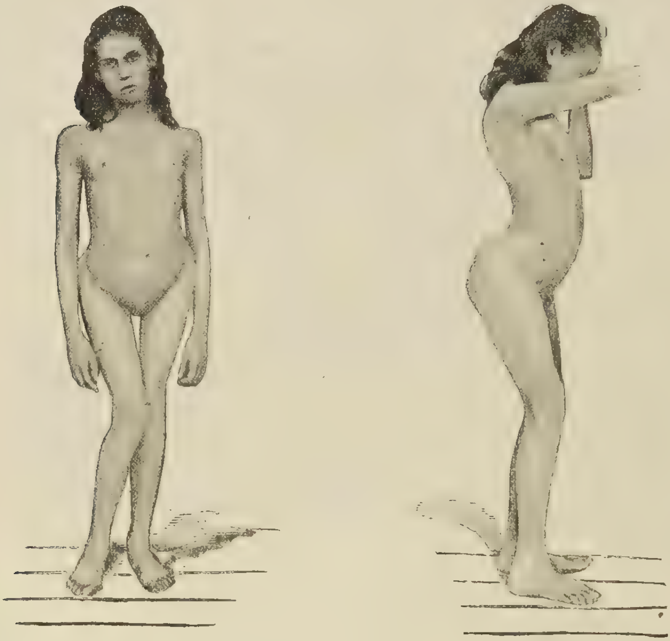

Fig. 165. Fig. 166.

Congenital Dislocation of Both Hips in a Girl of Fifteen Years, seen from the Front and Side. (From Photographs kindly lent by Mr. J. Jackson Clarke.)

stretched over the displaced head, and much thicker than usual; the ligamentum teres is elongated. The head of the bone is considerably altered and often much deformed; the acetabulum becomes triangular in shape, owing chiefly to want of growth of the iliac portion; whilst the muscles are necessarily modified as to their length. A new, but very imperfect, acetabulum forms on that portion of the dorsum ilii where the head of the bone rests.

Treatment is usually delayed until the child is two or three years old, and able to walk. In the meantime, if a diagnosis is made, the head of the bone is drawn down into the socket night and morning (a matter of no difficulty, as a rule), and worked about therein, with massage to the surrounding muscles. Some surgeons recommend the use of prolonged traction even at this early period.

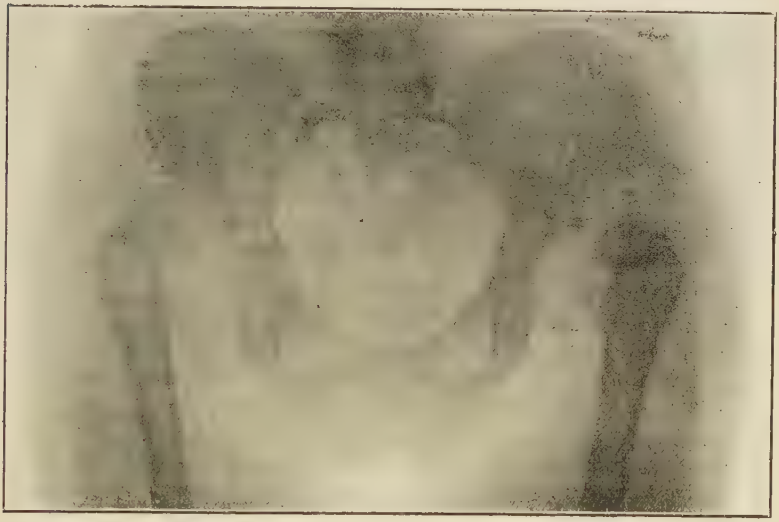

FIG. 167.—RADIOGRAM OF DOUBLE CONGENITAL DISLOCATION OF THE HIP-JOINT.

The noticeable points are the absence of the acetabular cavities and the displacement upwards and distortion of the heads of the femora.

At a later age (up to five or six years) Lorenz's *bloodless method of treatment* may be employed with some hopes of a successful issue, at any rate, in unilateral cases. (1) The head of the bone is first drawn down to the level of the acetabulum. Some surgeons recommend this to be effected by gradual extension; others do it at one sitting under an anæsthetic. The adductor muscles are the chief hindrance, and will require a good deal of kneading, or even possibly section with a tenotome. The anterior and posterior muscles must also be fully stretched by forcible flexion and hyper-extension of the limb. (2) The head of the bone is to be replaced in the acetabulum, and as this cavity is small and chink-like, and sometimes covered in by the front of the capsule, a good deal of difficulty may be here experienced. The limb is fully flexed and then firmly abducted, extended and everted; upward pressure from behind, as by the fingers or the insertion behind the trochanter of a leather-covered wedge (Lorenz), may be of assistance. The head of the bone can sometimes be felt to slip into the acetabulum, and the manœuvre should be repeated several times, as it were, grinding the head of the femur into the cavity. (3) The limb is then put up in plaster of Paris from the pelvis to the knee in a position of abduction and slight eversion, and with the leg hyper-extended. It is maintained in this position for ten or twelve weeks, and it is well to ascertain by radiography that the bone has not slipped. At the end of that period it will probably be found that a less degree of abduction will suffice in order to keep the bone in place, and a fresh case of plaster is applied with the limb in this new position, the extension and outward rotation being maintained. As soon as possible the child is encouraged to walk on the limb in this position of abduction, so as to force the head of the bone still deeper into the acetabulum; crutches are required at first, but he will soon do without them. The plaster casing is usually needed for six months, and then massage and exercises will be required.

Where actual reduction has failed, benefit is often obtained by forcing the head of the bone forwards into the neighbourhood of the anterior superior spine; the gait is manifestly improved by diminishing the tilting of the pelvis and the lordosis.

In older children (from five to ten years) treatment by *open operation* can be undertaken. The joint is opened from the back or front, the head of the bone is shaped up, the acetabulum enlarged so that the head can be replaced in it, and any tense structures divided which prevent reduction. The limb is subsequently immobilized in a position of eversion and abduction, but for as short a time as possible. Even if ankylosis results, the patient's gait is considerably improved.

Coxa Vara, or incurvation of the neck of the femur (Fig. 168), is a condition in which the neck of the bone, instead of passing obliquely upwards, is horizontal, or in bad cases directed downwards, whilst shortening from interstitial absorption also occurs, and the head becomes mushroom-shaped. At first the osseous tissue is softened, but after a while sclerosis supervenes. It is met with in children as a result of rickets, or perhaps more frequently in young adults, when it is sometimes due to the adolescent form of the same disease. Certainly it is seen most frequently in those who have to do much walking or carrying of heavy weights. In some cases it results from a gradual slipping down or traumatic separation of the epiphysis, which constitutes the head of the bone, or from a fracture of the neck in a child, followed by yielding of the callus.

The **Symptoms** commence with pain in the region of the hip, followed by a distinct limp. As the neck of the bone becomes absorbed or curved, the trochanter rises above Nélaton's line, and real shortening of the limb occurs, even up to 1½ inches. The limb is also everted and the trochanter increasingly prominent, especially on flexing the thighs. Internal rotation and abduction of the joint are limited, the latter being practically impossible in the more severe cases, owing to the base of the trochanter hitching against the lip of the acetabulum. On flexing the limb, the thigh sometimes lies across the sound one, whilst in the later stages the adduction may be so marked as to constitute a scissor-legged condition. As distinguishing features may be mentioned: the absence of local swelling or tenderness on pressure, as also of the up-and-down movement on traction, so well marked in congenital dislocation, whilst suppuration never follows, and thickening of the trochanter is not observed.

Treatment.—In the early stages rest is *the* essential, and thereby any increase in the deformity already existing is prevented; local massage and manipulation are also advisable, whilst in children prolonged extension with inversion may do good. In the later stages, sub-trochanteric osteotomy, in order to alter the axis of the bone, is perhaps the best measure to undertake, although a cuneiform osteotomy of the neck is recommended by some. The subsequent shortening may be dealt with by means of a thick sole on the under surface of the boot.

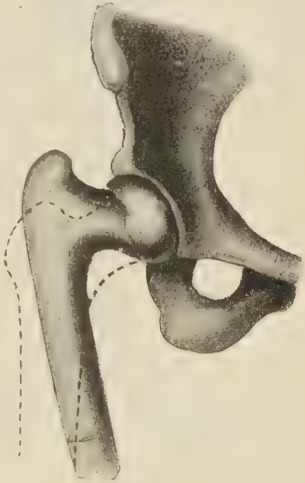

FIG. 168.—COXA VARA.

The dotted lines represent the normal neck of the femur.

Coxa Valga is the term applied to the opposite deformity, in which the axis of the neck of the femur approaches more to that of the shaft, and the angle of inclination between the two is greater than the normal 125°. It is usually secondary to congenital dislocation or infantile paralysis, and largely due to the absence of the transmission of the body-weight. The limb is usually abducted and rotated outwards, and there is some limitation of adduction and internal rotation. The trochanter is flattened and displaced below Nélaton's line. **Treatment**, if necessary, is usually directed to the cause; but if the resulting limp is seriously noticeable, a sub-trochanteric osteotomy may be desirable.

Congenital Affections of the knee are mainly connected with the patella, which is sometimes absent, and then other deformities are associated with its non-development. The extensor tendon passes down the front of the knee as a thick band, and the function of the joint is not much impaired.

Congenital Dislocation of the Patella may be present as a persistent lesion, the bone lying to the outer side of the joint; but more commonly the displacement only occurs at intervals, and then produces acute pain followed by synovial effusion. Replacement is easy when the joint is extended. The **cause** of the trouble is either an imperfect development of the external condyle of the femur or abnormal laxity of the capsule. Genu valgum may be associated with the former, and paralysis of the extensor muscles with the latter. **Treatment** consists either in tightening up the capsule and synovial membrane by excising a portion on the inner side of the patella, or in correcting the genu valgum. Some surgeons have chiselled off the tubercle of the tibia with the attached ligamentum patellæ, and refixed it on the inner surface of the tibia.

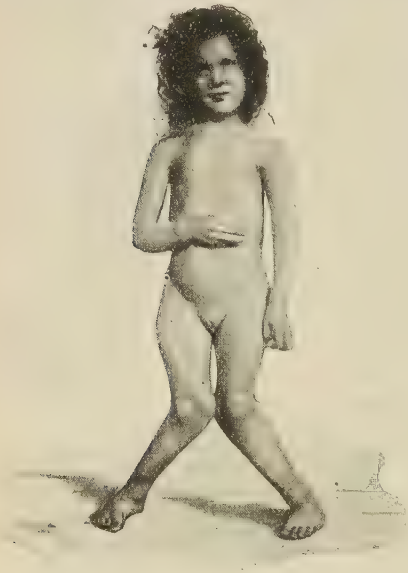

Fig. 169.—Genu Valgum of Rachitic Origin.

The patient was a child aged twelve years, and the cause of the deformity was rickets. The femora were curved antero-posteriorly, but radiography demonstrated that the trouble in the right leg was as much tibial as femoral in origin. Cuneiform osteotomy of both tibia and femur was needed on the right side, whilst simple osteotomy of the femur sufficed to correct the left side.

Genu Valgum, or *knock-knee,* is a deformity in which, if the knees are allowed to touch with the patellæ looking forwards, the malleoli are separated one from the other—*i.e.,* it is a condition of fixed abduction of the legs from the middle line, with some external rotation (Fig. 169). One or both limbs may be affected, but if due to general causes the double form is more common. Occasionally genu valgum occurs in one leg, whilst the other is in a condition of genu varum.

There are two main **varieties** of the disease, viz.: (1) The rachitic genu valgum of young children, and (2) the static form occurring in adolescents.

The genu valgum of young children arises from the irregular epiphyseal development induced by *rickets.* Increased growth occurs on the inner side of the joint, and this may involve equally the femur and tibia, although most frequently the former is mainly affected. When once the axis of the limb is altered, the weight of the trunk is transmitted chiefly through the outer portion of the joint, and development on this side is thereby hindered. In not a few cases an antero-lateral rachitic curvature of the diaphysis of the femur is an important element.

The static genu valgum of adolescents occurs most commonly in young people of relaxed constitution, and particularly in those who have to carry heavy weights. Thus, anæmic girls who act as nurse maids, and young bricklayers, smiths, and porters, are very liable to it. The method of origin is probably as follows: In the erect posture the femur is normally set at an angle to the tibia (which is vertical) in such a way that the weight of the trunk passes rather through the outer than the inner condyle, whilst the latter structure is lengthened in order to keep the plane of the knee-joint horizontal. This position naturally throws a certain amount of strain and tension on the internal lateral ligament, even in a healthy person (hence its insertion into the shaft and not merely into the upper epiphysis of the tibia); and this strain is increased when the natural position of rest—*i.e.*, with the feet separated and slightly abducted—is adopted. A long continuance of this posture tires those muscles on the inner side of the limb which tend to counterbalance this strain, especially if a certain amount of additional weight has to be carried, and particularly in those whose bones have rapidly increased in length and weight without any coincident increase in power of muscles or ligaments. Hence the internal lateral ligament becomes more and more stretched, and not unfrequently a certain amount of lateral mobility of the knee is noticed in the early stages. Subsequently the outer condyle becomes atrophied from more weight being transmitted through it, and the inner condyle becomes lengthened from overgrowth. Flat-foot and lateral curvature of the spine often accompany this form of genu valgum, the former being also usually due to ligamentous relaxation, whilst the latter may be merely compensatory if the deformity in the knee is unilateral.

Occasionally genu valgum is due to *traumatic causes*, such as fracture of the tibia or femur close to the joint, or lateral dislocation of the knee; whilst, again, it may be caused by atrophy consequent on interference with the epiphysis from local injury or diseases other than rickets. It is sometimes observed, as a result of riding, in those with long legs, as in cavalry soldiers; short-legged individuals, such as jockeys, are more liable to develop a condition of genu varum.

The **Physical Condition** of the parts about the knee may be summarized as follows: (*a*) The inner condyle of the femur is elongated and prominent; the increase in size is mainly in the vertical and transverse directions, and but very little antero-posteriorly, so that, on flexion of the joint, the deformity to a large extent disappears; (*b*) impaired growth and atrophy of the outer femoral condyle and tibial tuberosity are present owing to the weight of the body being transmitted more directly through these structures; (*c*) relaxation of the ligamentous and muscular tissues takes place on the inner side of the joint; this, however, is not constant, especially in the later stages, or in cases which are stationary; (*d*) the tendons and ligaments on the outer aspect of the joint are contracted and shortened, especially the external lateral ligament, the ilio-tibial band, and the tendon of the biceps; (*e*) the patella tends to be thrown outwards, and in bad cases recurring dislocation is sometimes observed; (*f*) in rachitic cases a localized bony outgrowth can usually be detected on the inner surface of the tibia about 2 or 3 inches from the joint, and probably due to a localized periostitis at the point of attachment of the internal lateral ligament.

The feet are displaced outwards, or occasionally inwards, as best suits the convenience of the patient in obtaining as good a footing as possible; the bones of the legs and of the thighs are often bent; whilst, if unilateral, scoliosis may result. In well-marked cases the gait of the patient is of a rolling or waddling type, and very characteristic. The legs are partially flexed, and as the condyles touch or overlap, they have to be separated at each step to allow of progression.

Treatment.—In *rachitic* cases, the infant requires the adoption of dietetic and therapeutic measures suitable to the condition present. For the local deformity absolute rest in bed is enforced; the limbs are well rubbed daily, and such manipulation and pressure employed as will help to straighten the limb. By perseverance slow but appreciable progress may be made until the deformity is corrected. In older children, splints may be applied on the outer side of the limbs, reaching from the waist or axilla down to the outer malleoli, or, if they are to be kept off their feet, beyond them. These are retained in position by water-glass bandages, put on firmly enough to draw the knees outwards. Such an arrangement is often sufficient in early cases to bring about a cure in the course of a few months.

In *static* cases the administration of tonics, such as iron and arsenic, combined with rest, massage, and possibly a change of air, will frequently suffice to determine a cure in the early stages. Suitable apparatus must be adopted when the patient is allowed to walk; that usually employed consists of an outside iron stem, jointed at the knee, fixed below into a slot in the heel of a well-made boot, and attached above to a pelvic band. From it several well-padded straps pass round the limb, and at the knee itself a much broader one covers the projecting inner condyle; by tightening these, the limb is drawn out towards the rod, and any increase of the deformity is prevented.

When, however, the osseous deformity is fixed, and the patient of such an age as to preclude the hope of a cure by mechanical means, *osteotomy* will be required, and the operation devised by *Macewen*, or some modification of it, is that generally employed. It consists in the division of the femur transversely about a finger's breadth above the upper border of the external condyle, so as to be well away from the epiphyseal cartilage. Macewen himself uses an osteotome* for the purpose, introducing it through an incision made ½ inch in front of the tendon of the adductor magnus, and turning it so as to lie at right angles to the long axis of the shaft; he divides the bone for three-quarters of its diameter, and breaks the remainder. A similar method may be employed from the outer side, the force used in breaking the inner layer of compact bone comminuting and compressing that portion, and so diminishing the deformity. Many surgeons, however, prefer to divide the bone with a saw, previously making a track for it along the front of the femur, and we certainly consider that such an operation is simpler, and equally efficacious. The limb, having been straightened, is either put up at once in plaster of Paris, or, perhaps, at first in a Gooch's splint, which allows the wound to be looked at and dressed, and subsequently in plaster. Union is complete in six weeks, but an immoveable apparatus should be kept on for three months.

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* An *osteotome* differs from a *chisel* in the fact that the former is bevelled on both sides, whilst the latter is merely bevelled on one side.

In a few cases due to rickets it may be necessary to divide the tibia just below the tubercle in addition to dealing with the femur. This is best accomplished as a first step, and the fibula will also have to be divided. When these wounds have consolidated, the femur is dealt with, if necessary.

Genu Varum is a less common condition, characterized by a fixed separation of the knees when the ankles are in contact (Fig. 170). It arises from three chief causes: (i.) Occupation, and particularly that of a jockey, the short legs being constantly apposed to the sides of the horse; (ii.) traumatism, especially if directed to the femoral condyles; and (iii.) rickets, the lesion usually present being a well-marked excurvation of the femoral shafts, with possibly a similar curve of the tibiæ (*bow-leg*). The condition is usually bilateral and symmetrical, but occasionally one side only is affected, whilst the other leg is in a state of genu valgum. **Treatment** in the early stage is by splints, in the latter by operation, which consists either in simple osteotomy above the knee, or in cuneiform osteotomy of the shaft of the femur.

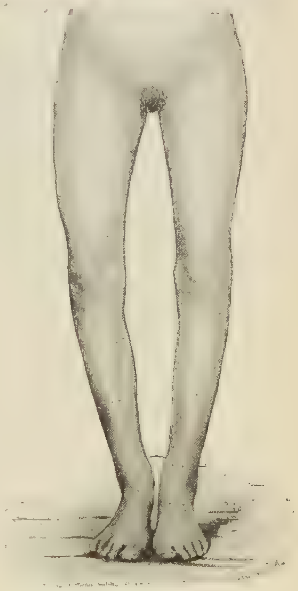

FIG. 170.—BILATERAL GENU VARUM.

The patient was a girl of thirteen years, who had developed this condition during two years, and was the subject of adolescent rickets. Enlargement of the epiphyseal ends of the radius and ulna, and of the costo-chondral junctions, was also present.

Genu Recurvatum, or *back-knee,* is a deformity occasionally met with, in which the joint is hyper-extended, the limb describing a curve with the concavity forwards; it is necessarily associated with relaxation or stretching of the crucial ligaments, and is usually due to a congenital displacement, possibly the result of the limbs not being flexed *in utero*, but extended with the feet under the chin. It is sometimes the result of paralysis of the extensor muscles, and is then due to the necessity for the patient to keep his knee fully or hyper-extended if it is to be a basis of support; in time the posterior ligaments give way, and deformity results. Genu recurvatum may also arise from irregular growth along the epiphyseal line, possibly as a sequela of tuberculous or other disease of limited extent in that region, and sometimes as a result of the disorganization of the joint in Charcot's disease. It has also been known to occur as an acquired accomplishment in fakirs and contortionists. Treatment must be suited to the special requirements of the individual case.

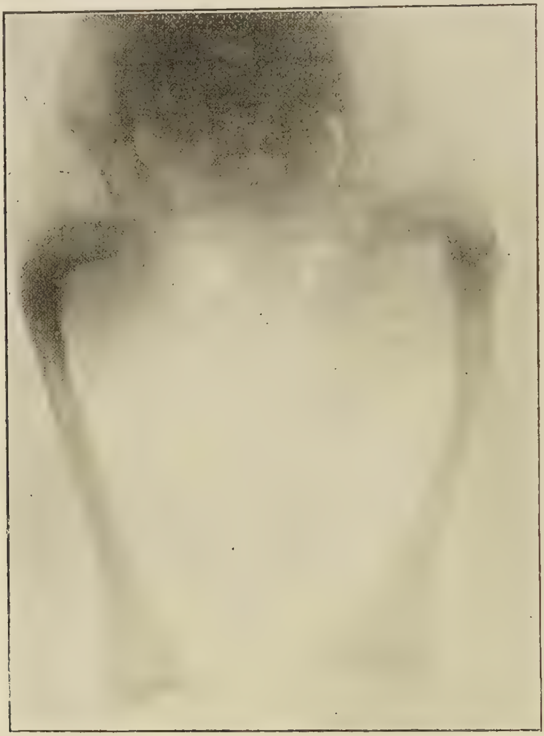

FIG. 171.—RADIOGRAM OF RACHITIC CURVATURE OF BOTH FEMORA IN A CHILD, AGED NINE YEARS, WHO HAD SUFFERED IN CONSEQUENCE FROM MANY FRACTURES. THE TIBIÆ ALSO SHOWED TYPICAL RACHITIC DEFORMITIES.

Rachitic Deformities of the Bones of the Leg are not unfrequent, if in the course of an attack of rickets a child is allowed to run about. The trouble may involve both segments of the limb, and give rise to a general excurvation, constituting what is known as *bow-legs*, the knees being widely separated the one from the other, and the antero-posterior curve being exaggerated. The femora are bent antero-posteriorly with the convexity of the curve forwards and outwards; the main convexity of the curve usually occurs about the junction of the upper and middle fourths, and here it may be so marked as to be a cause of spontaneous fracture. We have had a case of this nature under our observation for some years, where both femora had been frequently broken as a result of extreme rachitic distortion (Fig. 171). The *tibia and fibula* participate in this deformity, or are separately affected; the antero-posterior curve is usually increased, and some amount of abduction or adduction may also be present. The bones in these cases are flattened from side to side, presenting a sharp edge in front, with a buttress-like support or strut reaching along the concavity; they become exceedingly dense and sclerosed.

Treatment in the early stages consists of rest and constitutional treatment, and in the application of suitable apparatus to reduce the deformity. Where the femora are seriously affected, it may be necessary to provide the patient with apparatus (somewhat like a Thomas's knee-splint) which fits closely round the pelvis, and carries the weight to the ground by lateral metal rods which also maintain continuous extension. In the worst cases operation will be required, but never until all signs of active disease have passed. The bones may be divided at their most prominent part, or, if necessary, a wedge-shaped portion may be removed (*cuneiform osteotomy*), the sections being made at right angles to the upper and lower segments of the bone respectively. Careful and prolonged after-treatment, including the use of suitable splints, is required, especially where the femora have been divided, in order to prevent a reappearance of the deformity.

The tibia and fibula also become distorted and curved antero-posteriorly as the result of *inherited syphilis;* this usually comes under notice at a later date than the rachitic change, and is due to a deposit of new bone under the periosteum rather than to bending. The deformity is purely antero-posterior, without lateral deviation, whilst the subcutaneous margin of the tibia is rounded, and not sharp as in rickets. Moreover, the curve generally involves the centre of the bone, whilst in rickets the chief deformity occurs either near the knee or a little above the ankle.

Talipes.

By talipes, or club-foot, is meant a deformity of the foot due to muscular, ligamentous, or osseous causes, the displacement occurring mainly at the ankle and mid-tarsal joints.

Causes.—Talipes may be congenital or acquired.

Congenital malformation is responsible for a certain percentage of the cases resulting from imperfect formation of the bones of the foot, occasionally from absence of the lower end of the tibia or fibula, or very rarely from intra-uterine paralysis of central origin. Other cases are due to *malposition* of the feet *in utero*, possibly resulting from a deficient amount of liquor amnii, as a result of which the feet are abnormally compressed and held in one position. Naturally the legs of the fœtus are in a state of flexion, and the feet usually in a position corresponding to that of talipes varus; it is easy then to understand that in an unusually small uterus this position may become fixed. Spina bifida in the lumbar region is occasionally associated with congenital talipes, which is then probably due to impairment of nervous control. The congenital variety is often hereditary, and may occur in several members of the same family, or be transmitted through many generations.

The *acquired* varieties arise from some derangement of the equilibrium normally maintained between opposing groups of muscles, in consequence of which the more powerful group draws the foot into an abnormal position. Thus it may be due to: (*a*) *Paralysis* of central origin, one of the commonest causes of talipes; in young children this form is usually the result of infantile palsy (anterior polio-myelitis), whilst a similar affection is occasionally seen in adults. (*b*) *Cicatricial* contraction of muscles from diffuse suppuration, or arising from burns or disease of neighbouring bones; thus necrosis or caries of the tibia may lead to the formation of an abscess in the sheaths of the tibialis anticus or posticus, and contraction of one or both of these muscles may cause talipes varus. (*c*) Essential muscular shrinking, resulting from a chronic myositis fibrosa, is occasionally met with in elderly people. (*d*) Affections of the main peripheral nerve-trunks of the leg also lead to talipes. If the internal popliteal nerve is involved, talipes calcaneo-valgus will ensue, whilst a lesion of the external popliteal nerve produces talipes equino-varus, but never to any marked degree. (*e*) Certain diseases of the cord of a sclerosing type occasionally cause a *spastic* variety of talipes. (*f*) Shortening of the leg from hip or knee mischief often induces a *compensatory* talipes equinus, whilst injuries or diseases of one of the epiphyses of the leg bones may stop its growth, and then the continued development of the other bone forces the foot to one side or the other. (*g*) It is a question whether the condition known as flat-foot, arising from prolonged standing, is to be classed as a form of talipes; some surgeons draw but little difference between it and talipes valgus. (*h*) Finally, prolonged maintenance of the foot in a bad position may lead to permanent deformity, as in the variety known as talipes decubitus.

Four primary forms of talipes are described, viz.: **T. Equinus,** in which the heel is drawn up, the patient walking on the toes (plantar-flexion); **T. Calcaneus,** in which the toes are raised from the ground (dorsi-flexion); **T. Varus,** in which the anterior half of the foot is adducted and inverted, and the inner side of the foot is raised, the patient walking on the outer; and **T. Valgus,** due to abduction and eversion of the anterior half of the foot, or to yielding of the longitudinal arch on the inner side. Not unfrequently mixed forms occur, due to the association of two of the above—*e.g.*, T. equino-varus, or T. equino-valgus, or T. calcaneo-valgus.

As to the *relative frequency* of these different forms, there is not the slightest question that T. equino-varus is by far the commonest. If, however, we exclude congenital cases and flat-foot, T. equinus is in all probability the variety most frequently observed.

Talipes Equinus (Fig. 172, A, B, and C) is almost always acquired; as a congenital lesion it is very uncommon. It is usually due to paralysis of the extensor muscles, either from infantile palsy or injury to the anterior tibial nerve; secondary contraction of the calf muscles follows, the tendo Achillis being tense and rigid. It also occurs as a compensatory manifestation where the limb has been shortened, as after hip disease, and may result from prolonged pressure of the bed-clothes on the dorsum of the foot of a bed-ridden patient (T. decubitus).

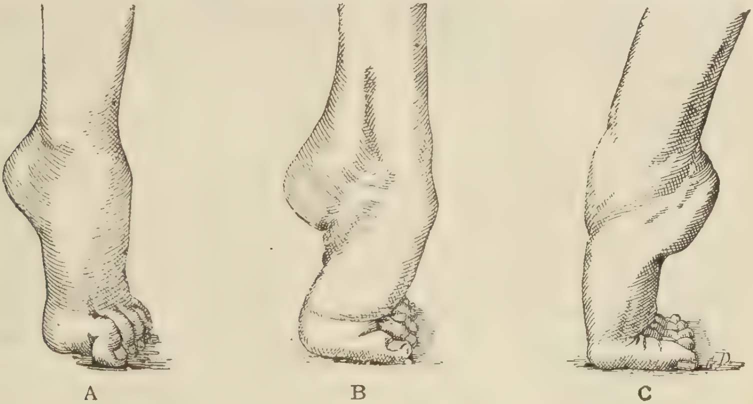

Fig. 172.—Various Forms of Talipes Equinus

In the slightest cases all that is noticed is that the foot cannot be dorsi-flexed beyond a right angle (right-angled contraction of the ankle). When more marked, the heel is drawn up, and the patient walks on the heads of the metatarsal bones and on the toes, which are usually hyper-extended. In neglected cases due to paralysis, the toes sometimes become plantar-flexed, the patient walking on their upper surface (Fig. 172, C); the whole dorsum of the foot may even in time be turned downwards. The astragalus is displaced forwards from under the malleolar arch, only the posterior part of the articular surface being in contact with the tibia. In the paralytic type the anterior segment of the foot drops at the mid-tarsal joint, so that the head of the astragalus and scaphoid constitute a marked prominence beneath the skin. In all cases the sole of the foot is shortened by contraction of the plantar fascia and of the short plantar muscles (pes cavus), and a certain amount of varus is frequently present.

In this, as in all forms of talipes, callosities, and perhaps bursæ beneath them, form over points of pressure—viz., under the heads of *all* the metatarsal bones.

Talipes Varus, or, as it is most frequently termed, **Equino-varus,** is the commonest variety of congenital club-foot, and is then often bilateral, and may be accompanied by other congenital defects—*e.g.*, hare-lip or spina bifida. As an acquired deformity, T. varus is not a very unusual result of infantile palsy affecting the extensor and peroneal muscles; other cases are due to a primary spastic contraction of these muscles.

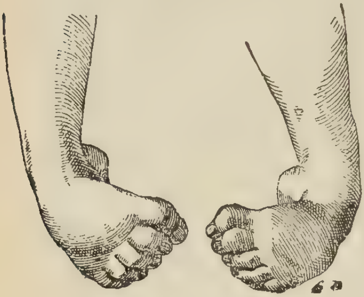
FIG. 173.—DOUBLE TALIPES EQUINO-VARUS OF CONGENITAL ORIGIN.

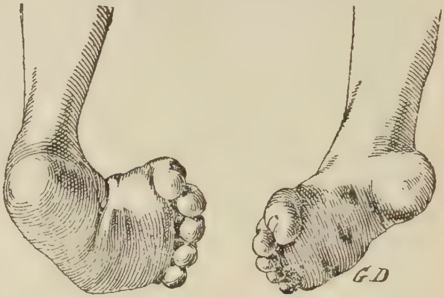

FIG. 174.—THE SAME, SEEN FROM BEHIND.

The heel is drawn up, and the anterior half of the foot adducted and drawn inwards (Figs. 173 and 174). The inner border of the foot is concave, and a well-marked transverse crease crosses the sole on a level with the mid-tarsal joint; the outer border is convex, and in adults who have walked a thick bursal formation is usually present over the cuboid. In neglected cases the patient may even stand on the dorsal aspect of the latter bone (Fig. 175). The sole of the foot is arched from secondary contraction of the plantar fascia and short muscles of the sole, and a longitudinal crease may run down the centre of the sole, owing to doubling over of the outer metatarsal bones

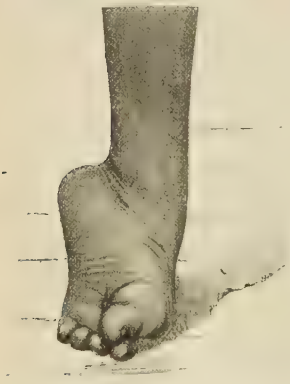
FIG. 175.—NEGLECTED CASE OF TALIPES VARUS.

The most marked *anatomical changes* in the congenital type are found in the astragalus, the neck of which is elongated and inclined inwards at an angle of 50° or more to the body of the bone; the bone also projects forwards from under the tibio-fibular arch, the posterior portion of the upper articular facet alone remaining in contact with it. The scaphoid is displaced to the inner side of the head of the astragalus, and its tubercle is usually in close proximity to, or may even touch, the inner malleolus. The os calcis and other tarsal bones are also modified in position and shape to correspond with these changes. The dorsal tendons are displaced inwards, usually occupying the centre of the concavity between the foot and the leg. The ligaments on the inner side of the foot are contracted, especially the anterior portion of the deltoid, the inferior calcaneo-scaphoid, and to a less extent the long and short plantar ligaments.

The following table (slightly modified from Mr. Tubby's work on Deformities*) indicates the chief diagnostic points between congenital and paralytic T. equino-varus:

	Congenital.	Paralytic.
History	Affection has existed from birth.	Affection not developed till the second or third year, and ushered in by convulsions, fever, etc.
Feet affected	Usually bilateral.	More often unilateral.
Circulation	Good.	Feeble; limb is sometimes cold, blue, and clammy.
Muscles	But little wasting.	Extreme wasting.
Electrical Reactions	Not much impaired.	Almost entirely absent in paralyzed muscles.
Growth of Bones ..	Much as usual.	Considerably diminished.
Creases in Sole	Present.	Absent.

Talipes Calcaneus is an unfrequent variety of the deformity, and may be either congenital or acquired. In the *congenital* form (Fig. 176) the toes are drawn upwards so that the heel alone comes into contact with the ground, the sole pointing forwards. The extensor tendons are contracted, but the toes may be flexed owing to the tension of the flexor longus digitorum. It is sometimes

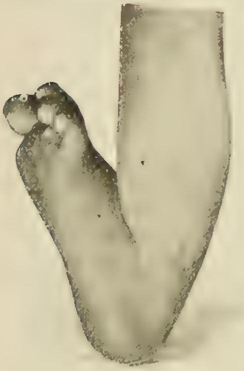

Fig. 176.—Congenital Talipes Calcaneus.

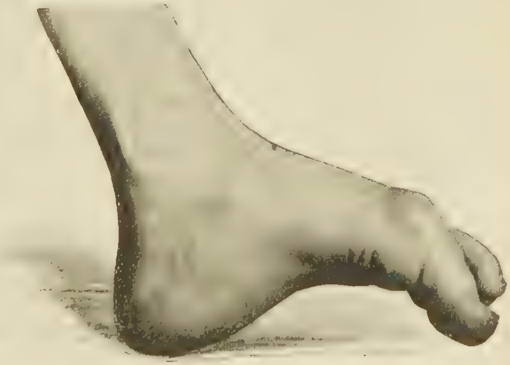

Fig. 177.—Paralytic Talipes Calcaneus, with Well-marked Hallux Flexus.

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* Macmillan, 1896, p. 398.

associated with deviation of the foot inwards or outwards, constituting a condition of T. calcaneo-varus or -valgus. The *acquired* variety (Fig. 177) is generally due to infantile palsy of the calf muscles, or occasionally to overstretching of the tendo Achillis after tenotomy. The longitudinal arch of the foot is increased (pes cavus), partly from the development of a large pad of fat over the calcaneal tuberosities, but mainly from the dropping of the anterior half of the foot from the mid-tarsal joint.

Talipes Valgus is a condition seldom met with as a *congenital* deformity, except in association with T. equinus. In it the foot is abducted and everted, owing to contraction of the peronei muscles. The sole becomes flattened, and the inner border of the foot comes in contact with the ground (Fig. 178). Considerable pain is usually experienced after walking a short distance. This deformity is occasionally due to absence of the fibula. The *acquired* variety, which is not uncommon (Fig. 179) results from paralysis of the tibial muscles, or from spastic contraction of the peronei, the condition in these cases closely simulating flat-foot.

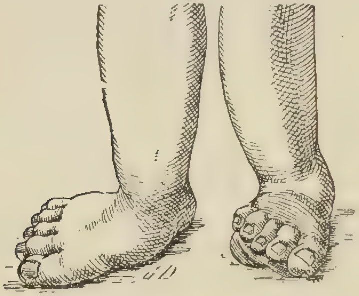

Fig. 178.—Talipes Valgus (Congenital), with a Little Tendency to Calcaneus.

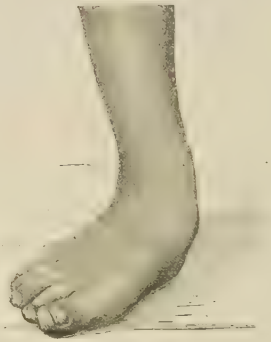

Fig. 179.—Paralytic Talipes Valgus.

The **Diagnosis** of the different varieties of talipes is, as a rule, easily made, although the cause of the deformity is not always so readily ascertained. In *paralytic* cases the limb is generally atrophied, bluish in colour, and feels cold and clammy. Trophic lesions are not uncommon in the form of recurrent ulceration, and even ulcers of the perforating type may develop, especially in cases due to nerve lesions, whether central or peripheral. The trouble is often unilateral, and the muscles are wasted and flabby. In *congenital* cases the condition is usually symmetrical, and of course present from birth; considerable resistance is felt on any attempt being made to correct the deformity, and the limbs look healthy, are well nourished, at any rate at first, and free from trophic lesions. In *spastic* cases (most frequently T. equinus) spasm or contraction of other parts is usually present, which renders the diagnosis obvious; one or both limbs may be affected; the reflexes are exaggerated; the gait is characteristic; and the muscles, at first firmly contracted, may finally atrophy.

The **Treatment** of talipes is always tedious, demanding care and patience on the part of all concerned. In the congenital variety no time should be lost in correcting the deformity, and, in fact, treatment should commence as soon after birth as possible. The nurse must be instructed to manipulate the foot into a good position, holding it there for some time daily, and the medical attendant may attempt more forcible correction two or three times a week. At the same time the muscles on the offending side of the limb should be rubbed and stimulated. In the early stages of the paralytic variety friction and faradization of the paralyzed muscles must be regularly undertaken. At a somewhat later date treatment by the application of suitable mechanical apparatus may suffice to restore the foot to its normal position. If this is unsuccessful, division of the contracted tendons, ligaments, and fasciæ will be necessary, whilst in severe and neglected cases more extensive operations in the shape of tarsectomy or tarsotomy may have to be performed.

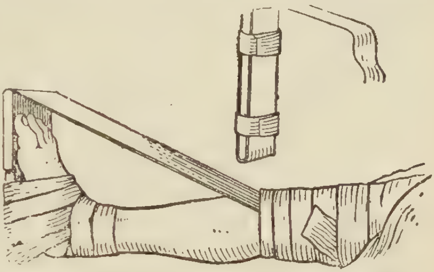

FIG. 180.—SAYRE'S APPARATUS FOR TALIPES EQUINUS.

The upper figure shows how the strapping is fixed to the plantar splint.

Talipes equinus, if secondary to hip disease, should not, as a rule, be interfered with. In other early cases it may be remedied by what is known as Sayre's apparatus (Fig. 180). This consists in the application of a plantar splint which projects slightly beyond the toes, and from the anterior end of which a piece of adhesive strapping is carried to just below the knee, to which it is applied and fixed by a firm bandage. Each day the bandage is carried a little lower down the limb, and as the traction of the strapping is thereby increased, the foot is gradually extended. In the more serious varieties tenotomy of the tendo Achillis may be required, accompanied, if necessary, by division of the plantar fascia, whilst in neglected cases, or where tenotomy has failed, excision of the astragalus gives most excellent results, the patient being able to walk subsequently with a plantigrade foot.

Congenital *T. equino-varus* may be treated in the early stages by applying to the foot a carefully-fitted malleable splint (Fig. 181), the shape of which is gradually altered so as to bring it in time to a normal position, or by a series of casings of plaster of Paris, a little improvement being obtained at each change. By care and patience many a cure will thus be obtained. In some cases the tendo Achillis and plantar fascia may be divided and the equinus and cavus elements cured, thereby rendering the varus condition more amenable to pressure.

In cases where such early treatment has not been undertaken, or where the deformity has not been improved thereby, *forcible correction* may be attempted. The child is placed under an anæsthetic, and the foot is forcibly wrenched and moulded into a good position, a Thomas's wrench being employed, if need be. It is essential that the foot should remain in good position when all force is removed from it. Possibly division of the tibial tendons may assist in this procedure, as also section of the tense ligaments on the inner side of the foot (*syndesmotomy*), but if such can be avoided, so much the better. The foot is then placed in plaster of Paris for five or six weeks, and subsequently massage and suitable exercises are employed before walking is allowed.

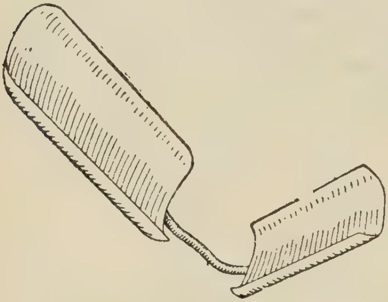

FIG. 181.— MALLEABLE SPLINT FOR TREATMENT OF CONGENITAL TALIPES EQUINO-VARUS.

It consists of two plates of metal, shaped to fit the sole of the foot and the lower part of the leg respectively; these are united by a malleable curved bar of copper. The foot-piece is first fixed, and then the foot brought into as good a position as possible, and the leg-piece bandaged on. Each week the foot-piece is bent a little more towards the normal position.

It is, however, only in the early stages that such treatment is advisable. At the age of eighteen to twenty-four months considerable growth of the limb has determined such osseous development as almost forbids one to expect benefit from it, without the exercise of undue force. Hence, if treatment is not commenced till the child is two years of age, and still more if the child has walked or is older, other methods must be employed. Of these, two chief plans have been advocated, viz., tarsectomy and Phelps' operation.

1. In *tarsectomy*, a wedge-shaped portion of bone is removed from the outer aspect of the foot. This is accomplished through a semilunar incision on the outer aspect of the foot; the thick subcutaneous structures, including the bursa, are removed, and the extensor tendons, already somewhat displaced inwards, are stripped from the bones and held aside. The tarsus is divided by a chisel in two places in such a way that a wedge of bone can be removed, the base being on the outer aspect, and the apex on the inner. The position of the joints need not be taken much into consideration, and as far as possible the sections are made at right angles to the anterior and posterior segments of the foot respectively, sufficient bone being removed to allow the foot to come into good position without difficulty. After closing the wound, the foot is kept in position, at

first by ordinary splints and subsequently by plaster of Paris for six or eight weeks. The results are excellent, the foot, although a little shortened, being firm and plantigrade. 2. *Phelps' operation* consists in dividing all the structures on the inner aspect of the foot through a vertical incision, starting above just in front of the internal malleolus. The mid-tarsal joint is usually opened, tendons and ligaments are divided, and the foot put up in a good position with the wound gaping. Healing may be accelerated by skin grafting. The results are at first quite as good as those attained by tarsectomy, but the deformity is likely to recur as cicatrization advances. In successful cases the longitudinal arch of the foot is lost, and the cosmetic result is anything but perfect, whilst the patient usually requires an instep support. In our opinion tarsectomy is much the better operation, and even when undertaken in children need not interfere with the subsequent growth of the foot.

In *paralytic Talipes varus* the foot will probably remain weak and flail-like in spite of treatment, and a suitable boot with leg irons to steady it will be required. The character of the treatment necessarily varies with the extent of the paralysis, but occasionally help is obtained by displacing the attachment of a healthy tibialis anticus from the inner to the outer side of the foot. In very bad cases arthrodesis of the ankle (*i.e.*, its fixation by removal of the articular cartilage and subsequent synostosis) may secure to the patient a firm basis of support.

In congenital *Talipes calcaneus* all that may be needed is division or lengthening of the extensor tendons; but in the paralytic variety some form of apparatus must always be worn. Where the tendo Achillis is thin and attenuated, a portion of it may be excised, and the ends united by suture; or the tubercle of the os calcis into which the latter is inserted may be sawn off and re-attached by a nail or peg to the bone at a lower level (Walsham); but the prognosis in all forms due to paralysis is unsatisfactory.

Talipes valgus, if unrelieved by the application of suitable boots, may need division of the peroneal tendons, or in severer cases wrenching the foot into position, and fixation in plaster of Paris. Removal of a wedge-shaped portion of bone from the inner aspect of the foot may be undertaken, but is not very successful.

Flat-foot (*syn.* : **Splay-foot** or **Spurious Valgus**) is a condition frequently seen in young adults whose occupation exposes them to over-fatigue, or the carrying of heavy weights—*e.g.*, in nurse-girls or shop-boys. It occurs as a natural condition in many of the negro races, and is more often seen in long than in short feet. It also results from rupture of the inferior calcaneo-scaphoid ligament, fracture of the neck of the astragalus, of the sustentaculum tali, or of the greater process of the calcaneum (*traumatic flat-foot*).

Mechanism.—In the majority of non-traumatic cases it is due to relaxation of the inferior calcaneo-scaphoid ligament, which supports the under surface of the head of the astragalus, and thus keeps up the longitudinal arch of the foot. This in its turn is braced up by the tendon of the tibialis posticus and an expansion backwards therefrom to the os calcis, as also by the plantar fascia and ligaments, and by the short muscles of the sole. A rapid increase in the length and weight of the skeleton apart from an equivalent increase in strength of muscles and ligaments throws undue strain upon this structure, especially if the patient is suddenly exposed to long hours of standing or weight-carrying. The ligament stretches, the head of the astragalus sinks, the anterior portion of the foot becomes abducted at the mid-tarsal joint, and the typical splay-foot results. The tibialis posticus is often relaxed or even paretic, and the peronei tendons are in the later stages contracted. Occasionally the deformity is due to a gonorrhœal inflammation of the inferior calcaneo-scaphoid ligament, which becomes relaxed and yields under the weight of the body. However produced, the *deformity* is tolerably characteristic (Figs. 182 and 114). The sole of the foot is flat, and in well-marked cases comes in contact with the ground throughout the whole of its extent. The inner border is convex and somewhat lengthened, whilst the anterior half is abducted. The head of the astragalus is felt a little in front of and below the internal malleolus, whilst the sustentaculum tali, which is normally distinguishable about ¾ inch below the malleolus, is buried by this displacement. The tubercle of the scaphoid is less evident than usual, being situated below and in front of the head of the astragalus. In the early stages the patient complains of a sensation of fatigue or weakness along the inner side of the leg, foot, or ankle, increased by exertion. Later on, the gait becomes somewhat shuffling, and severe pain is experienced, not only in the sole, but also on the dorsum over the astragalo-scaphoid joint. Sometimes it is extremely marked in the metatarso-phalangeal joint of the great toe, which may be enlarged and inflamed, owing to an associated chronic arthritis (*vide* Hallux rigidus).

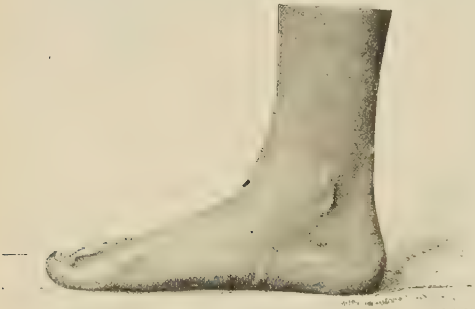

FIG. 182.—FLAT-FOOT.

Treatment.—In the earliest stages, when the deformity, though threatening, has not yet actually developed, all that is required in many cases is rest, so as to allow the overstrained muscles and ligaments to recover themselves; at the same time the parts should be massaged, and tonics administered to improve the general health. Square-toed boots without high heels must be used, so as to check any tendency to a valgoid position of the foot, and the heels may sometimes be slightly thickened on the inner side. The patient must walk with the toes pointed forwards or even inwards, and in some cases assistance may be obtained by ordering him to sit cross-kneed, in the tailor position, so as to exercise a certain amount of constant pressure inwards upon the front of the feet. Regular exercises ought to be instituted, such as raising the body on tiptoe with the feet inverted; such can only be undertaken for a short time at first, but as the muscles regain their tone a longer period can be tolerated. In a later stage elastic tension applied to the sunken arch is sometimes useful; Golding-Bird's sling can be employed for this purpose. It consists of a loop of soft webbing passed round the ankle and then under the instep, its free end being drawn up on the inner side and attached to an elastic accumulator which is connected with a steel garter-piece (Figs. 183 and 184).

In worse cases a metal spring or instep pad may be required to support the foot whilst walking, but it must be remembered that it has no curative function, and indeed by its pressure tends still further to weaken the structures on the inner side of the foot. It must fit the instep accurately and be made to pattern for each particular case, extending from the root of the toes to the heel.

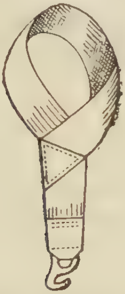

Fig. 183.—Mr. Golding-Bird's Sling of Soft Webbing for Supporting the Arch of the Foot.

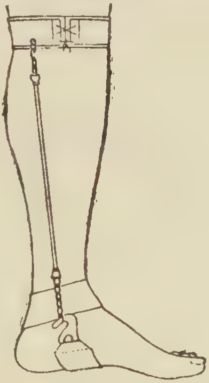

Fig. 184.—The Sling applied.

When the affection has reached a later stage, and the deformity cannot be remedied by ordinary manipulation, forcible rectification under an anæsthetic may be employed. The foot is firmly grasped in the two hands or in a Thomas's wrench (Fig. 185), and the anterior portion is forced inwards and backwards in such a way as to draw the scaphoid round the head of the astragalus as a fulcrum, and thus restore the arch. Probably a number of adhesions in the astragalo-scaphoid and other joints will be felt to give way during this manipulation. Tenotomy of the peronei is sometimes required before rectification of the position is possible. The foot is then put up in plaster of Paris and kept at rest for some weeks. Satisfactory results have followed.

In neglected cases operative proceedings may be necessary for the relief of pain. The removal of a wedge-shaped section from the inner side of the foot, and the production of bony ankylosis between the scaphoid and astragalus (as recommended by Ogston), is the only operative procedure worthy of consideration. Prolonged rest and a suitable course of exercises and massage will be required subsequently, whilst an instep pad may still have to be worn.

Pes Cavus (Hollow or Claw Foot) is a condition characterized by increased concavity of the plantar arch, so that when the individual stands there is a greater interspace than usual, if not an absolute break, between the impressions produced by the anterior and posterior segments of the foot (Fig. 172, B). Corresponding to the plantar concavity, there is a marked dorsal convexity, whilst the toes are generally in a condition to be immediately described as hammer-toe; the heads of the metatarsal bones are unduly prominent below, and callosities often form beneath them, causing considerable pain.

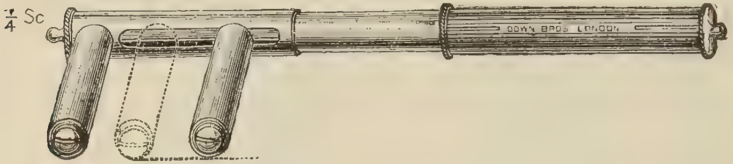

FIG. 185.—THOMAS'S WRENCH. (DOWN BROS.)

The two cross-bars are protected by thick indiarubber, and can be approximated or separated by rotation of the handle. The anterior portion of the foot is firmly grasped between them, one being placed on the dorsal and one on the plantar aspect, and forcible wrenching movements can then be carried out.

The condition is almost always associated with a slight degree of talipes equinus (right-angled contraction), and its method of production from this cause is as follows: The weight is normally carried to the ground mainly through the heel, but also partly through the toes; in these cases it is only transmitted through the toes and front of the foot, and since the anterior extensor muscles are probably weak, the short flexors act at an advantage, and by contracting draw the heel downwards so as to reach the ground, and thus the arch is increased. It is also seen in the paralytic form of *T. calcaneus*. **Treatment** in the early stages consists in friction applied to the weakened muscles of the leg, together, possibly, with the application of a splint to the sole. In more marked cases division of the tendo Achillis is needed, together with subcutaneous section of the tense plantar fascia. The deformity of the toes usually disappears when the equinus is corrected.

Hallux Rigidus (*syn.* : **H. flexus**) is a painful condition of the great toe, due to a chronic arthritis of its metatarso-phalangeal articulation. It usually occurs in young males with flat feet. The foot is abnormally long; its circulation is defective; the toe itself may be in good position, but not unfrequently the first phalanx is flexed (Fig. 177) and the distal one hyper-extended. It is probably due to abnormal pressure owing to the valgoid position of the foot, and possibly to wearing too short a boot. **Treatment.**—In the early stages correct the flat-foot, and see that suitable boots are worn. Failing this, careful strapping with Scott's dressing may give relief, but in bad cases excision of the head of the metatarsal may be required.

Hallux Valgus (Fig. 186) consists in a displacement outwards of the great toe from the median line of the body, as a result of which the other toes are huddled together, and in extreme cases the hallux is placed over or under them. It is present in the majority of people in some measure, owing to the usual shape in which boots are made; but in its severer forms it generally occurs in adult women, and is due to a chronic arthritis of the metatarso-phalangeal joint, the greater power of the adductor group of muscles explaining the deformity. The cartilaginous surface of the head of the first metatarsal bone becomes inflamed owing to the partial dislocation of the toe and the pressure of the boot; its structure and shape are thereby altered, and the joint is more or less disorganized. Two other conditions are associated with this deformity, viz., bunion and hammer-toe.

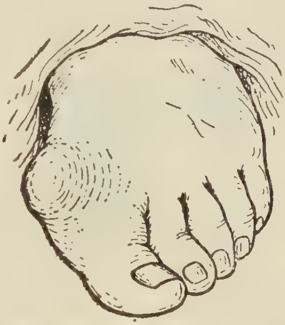
FIG. 186.—HALLUX VALGUS WITH BUNION.

A *bunion* consists in the formation of a bursa over the head of the first metatarsal bone, which becomes inflamed from cold or injury, and may even suppurate, the abscess often communicating with the joint, and leading to its disorganization. A marked bony outgrowth is usually found under the bursa, springing from the inner side of the head of the bone, and due to a localized chronic periostitis.

The **Treatment** of hallux valgus in its earliest stages consists in the use of correctly-shaped boots, with the inner border straight from toe to heel, whilst the sock or stocking should have a separate compartment for the great toe. The introduction of a toe-post between the great toe and its neighbour is sometimes effective in giving relief. In more severe types excision of the projecting head of the metatarsal bone gives admirable results. The operation is best conducted by turning up a flap of skin and subcutaneous tissues over the inner aspect of the head of the metatarsal with its convexity forwards. The bone is then divided by a chisel, and the head removed, allowing the toe to be easily replaced in a normal position. The skin is then laid down in place, and if need be shortened to meet the requirements of the case. Very rarely ought the second toe to be removed for this condition, as the lateral support of the great toe is thus weakened, and the deformity is probably aggravated. An *inflamed bunion* is treated by removing all local pressure, and applying fomentations. If the joint is involved in suppurative disease, excision of the head of the bone, or amputation of the toe, may be required. In less serious cases it may suffice merely to remove the thickened bursa, and to chisel away the projecting portion of the bone.

Hammer-Toe.—This deformity is constituted by hyper-extension of the first phalanx, marked flexion to an acute angle of the second, and either flexion or extension of the terminal phalanx, so that the first inter-phalangeal joint projects under the upper leather of the boot, whilst the patient walks on the extremity of the ungual phalanx, or even on the nail (Fig. 187). Callosities form upon the points of pressure (Fig. 188, 1, 2, and 3), especially on the dorsal aspect, and a subcutaneous bursa over the head of the first phalanx (4), giving rise to great pain and inconvenience. The second toe is that most frequently affected, with or without the others, but it is uncommon for the hallux to be thus deformed. The extensor tendons often stand out very evidently beneath the skin. The flexion of the second phalanx on the first is carried to such a degree that the former bone is semi-dislocated. The prolongations of the plantar fascia on either side are much shortened, and the lower portions of the lateral ligaments of these articulations are also contracted.

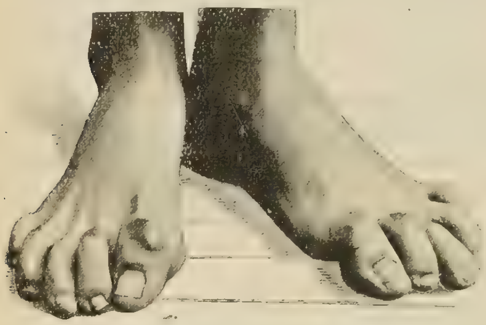

FIG. 187.—HAMMER-TOE DEFORMITY OF ALL TOES OF BOTH FEET WITH MARKED CALLOSITIES OVER THE HEADS OF THE FIRST PHALANGES.

In this case the patient, a girl of seventeen years, was quite crippled. Operation was performed on all the toes, the heads of all the first phalanges being removed, and an excellent functional result followed.

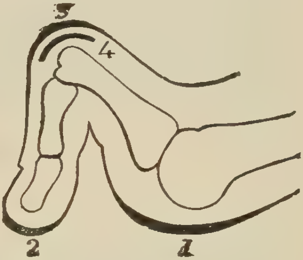

FIG. 188.—HAMMER-TOE. (AFTER KEEN AND WHITE.)

1, Callosity over head of metatarsal bone in sole; 2, callosity over end of toe; 3, callosity or corn over head of first phalanx; 4, adventitious bursa over the same bony point.

Causes.—It is occasionally congenital, but more often acquired, and then (*a*) it may be secondary to hallux valgus; (*b*) it may result from wearing short and pointed boots, or very high heels; in either case the toes are crowded together and drawn up out of the way of pressure; (*c*) it follows contraction of the plantar fascia, and is then associated with pes cavus and talipes equinus.

Treatment may be commenced by the use of correctly-shaped boots, but the case has usually progressed to such an extent when the patient is first seen that no palliative measures are of any avail. Operation is then necessary, and probably the second phalanx is so much displaced that nothing short of removal of the head of the first phalanx holds out any prospect of permanent relief. An incision is made longitudinally over the joint, the extensor tendon being split down the middle; the head of the bone is then cleared by the raspatory, and nipped off by cutting pliers. No splint is required, as the pressure of the dressings suffices to keep the toes in good position. Sometimes there is but little room between the great and third toes, so that even if one corrected the deformity of the second toe there is no space for it to lie comfortably; amputation should then be performed.

Metatarsalgia, or **Morton's Disease,** is characterized by severe pain of a neuralgic type located primarily about the head of one or more of the metatarsal bones, usually the fourth, but also radiating thence up and down the limb. It often occurs in gouty or rheumatic subjects, and may be attributed to some injury; a slight degree of flat-foot and the wearing of tight boots certainly predispose to it. It is probably due to compression of the digital nerves between the heads of the metatarsal bones and the ground. The foot is found to be broader than usual, and the anterior transverse arch formed by the heads of the metatarsals flattened out. Marked callosities, or corns, are observed on the under surface close to the heads of the bones, one or more of which may be unduly prominent below. In a few cases small bony enlargements have projected from the heads of the metatarsal bones, and in others definite fibrous growths have been found in the subcutaneous tissues; in other cases a simple peripheral neuritis may explain the manifestations. The pain is generally induced by walking, and comes on in characteristic paroxysms. Lateral pressure over the bases of the metatarsal bones often relieves the pain, but similar pressure over the heads usually increases it. Occasionally evidences of osteo-arthritis are manifested in one of the neighbouring joints.

Treatment consists in resting the foot, whilst suitable diet and drugs are ordered to combat any gouty or rheumatic tendency. At the end of a few weeks the patient may be allowed to walk again with boots which are low-heeled, thick-soled, and broad anteriorly. An instep pad may be employed, if flat-foot is present, and an attempt made to relieve pressure on the heads of the metatarsals by treating the callosities on the sole of the foot, and applying a transverse strip of felt plaster ($\frac{1}{4}$ inch thick) behind the heads. Morton's recommendation—viz., excision of the head of the projecting metatarsal bones—may be reserved for the more aggravated and serious forms; it is best effected through a longitudinal dorsal incision running parallel to the extensor tendons.

CHAPTER XX.

INJURIES OF BONES—FRACTURES.

Contusion of a Bone and of its periosteum is usually a matter of no great moment, although the part becomes painful and swollen. Occasionally a subacute periostitis is caused in people liable to rheumatism or gout, or in the subjects of syphilis; whilst in those who are thoroughly out of health, and with low germicidal power, acute infective periostitis or osteo-myelitis, resulting in necrosis, may supervene. The **Treatment** of an uncomplicated case consists merely in the use of cooling lotions or of a bandage, whilst if periosteal thickening results, iodide of potassium may be given, and iodine paint applied locally.

Bending of Bone may or may not be associated with fracture. Bending without fracture occurs mainly in children, and in adults is only the result of some local disease. More commonly a partial or green-stick fracture is produced (p. 474), and in this the deformity can generally be corrected without much difficulty.

Fractures.

A fracture may be defined as a sudden solution of continuity in a bone, usually resulting from external violence.

Predisposing Causes of Fracture—*Age.*—From two to four fractures are not uncommon, owing to the unsteady gait and frequent falls to which little children are liable; from four to six the bones often bend so as to cause green-stick fractures; up to the age of eighteen years injuries near joints induce separation of epiphyses; from six years onwards fractures increase in frequency, reaching their maximum between thirty and forty years of age; old people are liable to this form of accident, owing to the bones becoming atrophic or brittle.

Sex.—As might be expected, fractures are more common in the male sex during boyhood and adult life; but up to the age of four or five they are equally frequent in the two sexes, whilst after forty-five they are more common in women, owing to their great liability to intracapsular fracture of the cervix femoris and to Colles's fracture.

Morbid Conditions of the Bones predispose to fracture in a marked manner, often leading to what is known as *Spontaneous Fracture*, in which the determining force cannot be recognised or is very slight. Under this heading may be included: (1) Atrophy of bone, which may be of the senile type, as manifested especially in the cervix femoris; or is due to want of use, as in a paralyzed limb or from an ankylosed joint. (2) Patients afflicted with certain mental or nervous diseases, such as general paralysis or tabes dorsalis, are unduly liable to fracture, which may result from atrophy, but may also occur in apparently healthy bones. Thus, a man suffering from tabes was sitting with his thigh abducted and everted in order that he might examine and dress a perforating ulcer on the sole of the foot, when the shaft of the femur, subsequently shown to be of normal dimensions, and apparently of normal density, snapped in two. (3) Fragilitas ossium or osteo-psathyrosis consists in an inherited tendency to spontaneous fracture. It results in a multiplicity of fractures, occurring even in children; thus, a girl, aged twelve and a half years, had suffered from forty-one fractures since the second year of life. No explanation of this condition is known; the lesions often unite perfectly, though sometimes with a good deal of deformity. (4) General bone diseases, such as rickets and osteomalacia, also predispose to fracture; in the latter affection the bones often bend considerably before breaking, and there is usually but little attempt at repair. (5) Local bone disease may also constitute an important predisposing factor by weakening its structure. Thus, sarcoma and secondary cancer of bone are often first recognised by causing a spontaneous fracture; the erosion of an aneurism and the destruction of the para-epiphyseal region in acute osteo-myelitis may lead to a similar result.

The **Exciting Causes of Fracture** are threefold: (1) *Direct violence*, the fracture occurring at the spot struck, and being often transverse, not unfrequently comminuted, and sometimes complicated with injuries to the adjacent soft parts. (2) When due to *indirect violence*, the accident is usually produced by the compression or bending of the bone with such force as to exceed the limits of its natural elasticity, so that it yields at the weakest spot. Thus, when a person jumps from a height, the leg bones are compressed between the weight of the body and the resistance of the ground, and, if the violence is excessive, a fracture occurs at some point of mechanical disadvantage. If the stress falls chiefly on the shaft, an oblique fracture ensues, often with much longitudinal displacement, and possibly becoming compound; if an element of torsion is present, as by forced inversion or eversion of the foot, the fracture is likely to become spiral in type. If, on the other hand, the violence expends itself on a mass of cancellous tissue, such as the os calcis, astragalus, or upper end of the tibia, the bone may be fissured in various directions, comminuted, or even ' pulped '; such a condition is sometimes termed a *compression fracture*. (3) *Muscular action* is most commonly the cause of fracture of small bones or of osseous prominences, into which powerful muscles are inserted. The patella and olecranon are not unfrequently broken in this way, the former often occurring from sudden and vigorous efforts to avert a fall. Occasionally one of the long bones, such as the humerus or clavicle, has been broken by violent muscular exertion, as by throwing a cricket-ball.

Fig. 189. — Obstetric Fracture of Humerus in a Baby Four Weeks Old.

Intra-uterine Fractures are caused by blows upon the mother's abdomen, or by abnormal or violent uterine contractions, especially if the liquor amnii is deficient in amount, or if the formation of bone is defective, as in osteogenesis imperfecta (p. 586). They are usually followed by considerable deformity, which must be clearly distinguished from that due to imperfect development. **Obstetric fractures** also occur as a result of undue violence used by the accoucheur during delivery, usually affecting the shaft of the femur or humerus (Fig. 189).

Varieties.—A **Simple Fracture** is one in which the skin is unbroken or, at any rate, where the external air has no admission to the site of injury. A **Compound Fracture** is present when the skin or mucous membrane is so lacerated that there is direct or indirect communication between the fracture and the external air. In the base of the skull, a fracture may open up one of the deeper air-sinuses, and thus it becomes compound without any apparent external lesion. These terms, though sanctioned by the approval of centuries, are neither of them good, *subcutaneous* and *open* being preferable. A subcutaneous fracture is often anything but a simple injury, and may result in the most disastrous consequences, whilst an open fracture may be a matter of comparatively little importance. Indeed, with our present appliances and methods of treatment open fractures often give better results than those that are called simple.

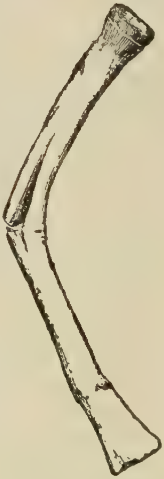

Fig. 190.—Green-stick Fracture of Radius.

Fractures are complete or incomplete, according to whether or not the continuity of the bone is entirely interrupted. Various forms of **Incomplete Fracture** are described, and indeed the introduction of radiography has shown that they are much more common than was formerly supposed. A *green-stick fracture* (Fig. 190) is one which only occurs in young children, and most often in those that are rickety; curved bones, such as the clavicle, are usually affected, and the fracture merely involves the convexity of the curve, whilst the concave half is bent, just as when a green bough or twig is partially broken. *Depressions* of the skull may be similarly incomplete when the outer table is driven in without fracture and the inner table alone splintered. *Fissured fractures* also are often only partial. A *sub-periosteal fracture* is one in which the periosteum remains intact, although the bone is broken; displacement does not occur, and therefore the injury is likely to be overlooked, apart from radiography.

Complete Fractures may be *transverse*, though this is not very common; *oblique*, arising usually from indirect violence; *spiral*, when the force acts in a rotary direction as well as longitudinally; it occurs most frequently in the tibia or femur, and the lower fragment often has a sharp triangular upper end, giving it somewhat the appearance of the mouthpiece of a clarionet (fracture *en bec de flute ;* Fig. 191). Not uncommonly a second fissure runs downwards from the main line of fracture, separating off a long narrow fragment of the shaft. A *longitudinal* fracture is one due to fissuring or splitting of the bone in its long axis; it is most common as the result of gunshot injuries. If it is combined with a transverse fissure, it is often termed T-shaped. *Comminuted* is a term used to describe the condition when the bone is broken into more than two pieces; *impacted*, when one fragment is driven into the other; *multiple*, when more than one fracture exists; *complicated*, when important structures, such as an artery or joint, are damaged as well as the bone.

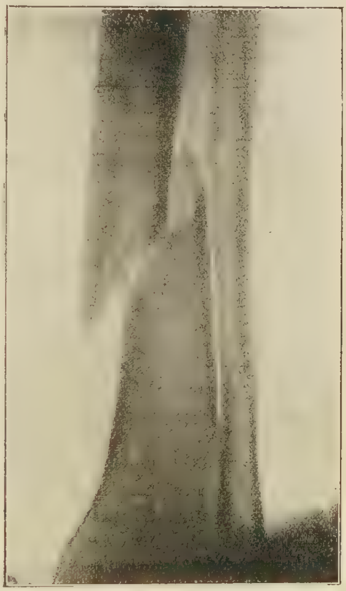

FIG. 191.—FRACTURE OF THE TIBIA: 'EN BEC DE FLUTE.'

There was but little shortening in this case; it was impossible, however, to reduce the deformity even under an anæsthetic, and operation was required.

The **Separation of an Epiphysis** results in young people from violence directed to the ends of the bones, but occasionally from pathological affections of the epiphysis or of the adjacent portion of the diaphysis—*e.g.*, from inherited syphilis, rickets, scurvy, suppurative osteo-myelitis, or tuberculous epiphysitis. The femur, humerus, or radius are the bones most often affected. The line of cleavage usually runs through the soft spongy tissue on the diaphyseal side of the cartilage, so that there is cartilage with spicules of bone on one side, and spongy bone on the other. In very young children, where the epiphysis is entirely or mainly cartilaginous, the lesion is almost always a pure separation of the epiphysis from the shaft; but at a later date it not unusually extends in part through the adjacent end of the diaphysis (Fig. 221). A marked feature is the stripping up of the periosteum, which, though loosely attached to the shaft and easily separated from it in children, is firmly adherent to the epiphyseal cartilage, and hence retains its connection with it, thus frequently limiting displacement. If, however, the force is sufficient, the end of the shaft penetrates the periosteum, which may grasp it closely, and this periosteal 'sleeve' may seriously hinder reduction. Union usually occurs by means of bone, and arrest of the longitudinal growth may follow if the parts are not replaced in exact apposition. This is a matter of importance when one of the bones of the leg or fore-arm is affected, since deformity of the hand or foot results if the injured bone ceases to grow and the uninjured one continues its development. Suppuration sometimes occurs as a sequela in unhealthy children, or when the accident is compound, and may result in acute osteo-myelitis and necrosis.

Partial detachment of an epiphysis (the *juxta-epiphyseal strain* of Ollier) often occurs, giving rise to phenomena similar to those of a sprain; if overlooked and neglected, it is likely to prove a fertile source of tuberculous disease, or may interfere with the growth of the limb. The essential feature is a more or less tender, but very distinct swelling of the bone close to the epiphysis, but the neighbouring joint remains unaffected. Treatment consists in immobilization in plaster of Paris.

Signs of Fracture.—The history usually given by the patient is that, as the result of some accident, he felt, or perhaps heard, something give way with a snap, and experienced sharp pain which became much intensified on attempting to move the limb. On examining the injured part and contrasting it with the opposite side, the following points are usually noticed:

1. The *signs of a local trauma*, viz., pain, bruising, and swelling, as a result of the effusion of blood from the torn and lacerated structures. The amount of this may be so great as to obliterate all the ordinary bony prominences and landmarks. Blebs and bullæ sometimes form over the surface in the course of a day or two, and these should be carefully protected from infection. The discoloration continues for some time, and may spread to parts far removed from the original mischief. This infiltration of the parts with blood often leads to considerable subsequent thickening, and possibly to serious adhesions and limitation of movement. It is unusual for suppuration to occur after a simple fracture, unless the patient is very debilitated and with diminished germicidal powers.

2. *Preter-natural mobility in the continuity of the bone* may be demonstrated by manipulation, but never unnecessarily. Impaction or non-separation of the fragments prevents its occurrence.

3. Partial or complete *loss of function* also follows.

4. *Crepitus** can only be felt when the fragments are moveable and can be brought into contact, but not when there is wide separation or impaction.

5. Change in shape of the limb or *deformity from displacement* results from three chief factors, viz., the direction of the violence, the weight of the limb, and the contraction of muscles, whilst injudicious movement or rough handling may aggravate it. It is always more marked in oblique than in transverse fractures, and hence is usually greater in those due to indirect violence. Various types of displacement are described, viz.: *Angular*, generally due to the unequal action of powerful muscles; *lateral*, where the displacement is merely to one or the other side, and most common in transverse fractures; *longitudinal*, when one fragment overlaps the other or is forcibly driven into it, causing shortening of the limb; it may also occur in the form of wide separation of the fragments, as from contraction of the quadriceps in fracture of the patella; *rotatory*, when one fragment is twisted on the other, as in fractures of the femur, where the weight of the limb causes eversion of the lower end. In flat bones—*e.g.*, the skull—deformity may exist in the shape of *depression* or *elevation*.

Radiography has proved of the greatest service both in connection with the diagnosis and the treatment of fractures. Many a case which would formerly have been called merely a sprain can now be demonstrated to be really a fracture (especially about the wrist), and the constant use of this procedure has revolutionized our ideas as to the relative frequency and also as to the nature of many such lesions. The following points must, however, be noted if the practitioner is not to be misled: In the first place, an assured diagnosis can never be made with the screen alone: the limb must be photographed, and for choice stereoscopically; otherwise the radiograms should be taken in two directions, antero-posteriorly and laterally. The importance of this latter precaution is indicated by a study of Figs. 226 and 227, or of Figs. 258 and 259. Then it must be remembered that all radiograms are more or less exaggerations, owing to the proximity of the tube to the limb, and that a deformity which is very obvious in the radiogram may in reality be comparatively slight. Moreover, too, the exact position of the tube and its angular relationship to the limb must not be neglected, as otherwise misleading interpretations may be given of the appearances presented. Finally, it must be remembered that callus is for a considerable time pervious to the X rays, so that, although the fracture is firmly united, it may be still visible in the radiogram.

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* The term *Crepitus* is applied to five different conditions which may produce a creaking or grating sensation to the examining hand. 1. *Bony* crepitus results from the rubbing together of the fragments in a fracture, or of the ends of bones in a joint when denuded of their articular cartilage. 2. A softer variety of bony crepitus is obtained when an *epiphysis* is detached. 3. An effusion of *blood* into the tissues gives rise to a soft crackling sensation on handling. 4. *Effusion* into tendon sheaths, bursæ, and joints also causes a soft crepitant sensation, varying in different cases. 5. *Air* in the tissues causes surgical emphysema and a characteristic form of crepitus.

General or Constitutional Effects.—*Shock* is greater or less according to the amount of violence and the seat of injury. It varies from a mere passing faintness to the severest prostration. If the bones of the head or spine are injured, special symptoms due to concussion of the brain or injury to the spinal cord may also be produced.

Hæmorrhage is rarely sufficient to give rise to general effects unless the fracture is compound, and involves some important vessel.

Fracture fever (aseptic traumatic fever, p. 268) is met with in the majority of cases, commencing twenty-four hours after the accident and lasting two or three days. As a rule, it is not severe, the temperature rarely rising above 100° F. in uncomplicated cases. In compound fractures where asepsis is not attained, any form of wound infection may result, and even general septicæmia or pyæmia.

Delirium tremens is a not unusual complication of fractures of the leg in debilitated individuals or habitual drinkers. The general characters and treatment of the disease are dealt with elsewhere (p. 270). As regards local treatment, the limb must be fixed by splints or encased in plaster of Paris, and suspended in a Salter's swing so as to prevent the patient from moving the upper fragment independently of the lower.

Fat embolism results from the absorption of broken-up fat globules after any injury which causes contusion or laceration of fatty tissue; when this is accompanied by tension from effusion of blood, as in fractures, this process is more likely to occur. Usually the great mass of the fat is filtered off by the lungs or eliminated by the kidneys (as can be demonstrated after death by staining with osmic acid), and no harm results. The pulmonary obstruction may, however, become so great as to lead to a fatal issue from dyspnœa; whilst if the cerebral vessels are blocked, syncope, or even coma, may be induced. The symptoms are gradual in their onset, and usually commence about the third day, but may not be evident for a week.

The **Union of Fractures** is brought about by a series of changes analogous to those which we have already seen occur in other wounds, except that they do not terminate in the formation of cicatricial tissue, but go on to the further development of bone.

When a fracture has occurred, the broken ends of the bone are left rough, spiculated, and more or less separated one from the other; the periosteum is torn, but the rupture is not always complete, a 'periosteal bridge' perhaps persisting and playing an important part in the reparative process, especially if the fracture is not accurately set. The muscles and neighbouring tissues are lacerated, and a varying amount of blood is extravasated, occupying the interstices of the wound. In the course of a few hours after the parts have been immobilized, the process of repair is inaugurated by the blood-clot becoming invaded by leucocytes, and after a time it is absorbed, the hæmoglobin passing through various stages of degeneration, and thereby staining the surrounding tissues. At the same time there is an exudation of plasma into all the injured and lacerated soft parts around, and the connective tissue cells proliferate actively. The periosteum becomes thickened and more vascular, and its connection with the bone is loosened for a short distance on each side of the fracture. The blood-clot, occupying the space beneath the loosened periosteum, is gradually transformed into granulation tissue, which unites with that derived from surrounding torn structures and from the bone itself, and this ovoid mass binding the fractured ends together is known as the *provisional or ensheathing callus* (Fig. 192).

The ossification of the callus is the next stage in the process. This is brought about by the activity of the cells in the deeper part of the granulation tissue, which are derived from the osteoblastic cells set loose by the injury and the resulting rarefaction. These retain their bone-producing potentialities, and hence bony spicules develop in the substance of the deeper parts of the granulation tissue, as also from the surface of the uncovered ends of the fragments, and from the under side of the periosteum. This latter membrane when it is stripped from the underlying bone draws with it certain bone cells, accompanying the small vessels which pass from the membrane into the Haversian canals, and from these the bone develops. Ossification thus starts from many foci, and the callus is quickly converted into a mass of bone, which is at first soft and spongy, but after a time becomes firm. When a periosteal bridge has been left, bone formation commences on its under surface, and not unfrequently in radiograms a line of newly-formed bone can be seen passing from one fragment to the other, and evidently due to this cause.

The medulla becomes hyperæmic for some distance from the seat of fracture and is transformed into granulation tissue, which unites with that springing up from the opposite fractured surface. Fine spicules of bone gradually permeate the granulation mass until the whole is ossified, constituting the *internal callus*, or, better, the *medullary plug*.

Naturally, the compact bony tissue is the last to engage in these changes, and the denser the bone, the longer they are in being completed. The fractured ends become hyperæmic and rarefied, the bone cells proliferating, the medullary contents of the Haversian canals increasing in amount, and the actual osseous substance being absorbed, until the rough and spiculated surface becomes smooth and covered with granulations. These unite with the medullary plug, of which they may indeed be looked on as an extension, and finally give rise to the annular bond of union between the two layers of compact bone, to which was originally applied the name *definitive* or *permanent callus*.

It will thus be obvious that the continuity of a bone is restored long before repair is completed, and that it mainly depends on the ossification of the provisional callus, the amount of which is to some extent proportional to the degree of mobility of the fragments. A certain amount of cartilage is often developed in the process of bone-formation, especially in young people, and where there is much mobility; it is present chiefly in the early stages, and mainly in the ensheathing callus. The newly-formed osseous tissue is at first soft and spongy, but gradually becomes denser; at first it is easily detachable from the underlying bone, but later on becomes continuous with it. As the so-called definitive callus becomes stronger, the ensheathing callus diminishes, and finally, if the ends are in good position, may vanish entirely, whilst the medullary plug may also be totally removed. Thus it is possible for the bone, under these circumstances, to be restored so absolutely as to show no signs of its having been fractured.

When the ends of the bones partially overlap (Fig. 193), the amount of ensheathing callus is considerably increased, and fills up all the spaces left by the overlapping of the fragments. The projecting edges of bone become rounded off, and the medullary cavities closed by plates or plugs. The main bond of union is the ensheathing mass, a considerable portion of which persists. Some deformity is sure to remain, and it is unusual for the medullary canal to be restored.

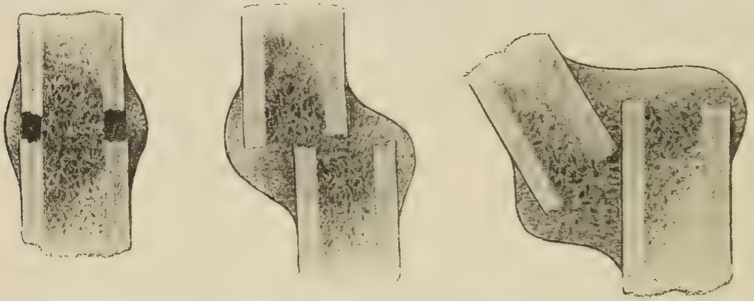


FIG. 192. FIG. 193. FIG. 194.

DIAGRAMS TO REPRESENT UNION OF FRACTURES: FIG. 192, WHEN THE ENDS ARE IN CLOSE APPOSITION; FIG. 193, WHEN THE ENDS ARE ONLY PARTIALLY APPOSED; AND FIG. 194, WHEN THE FRACTURED SURFACES ARE NOT IN CONTACT AT ALL.

If the fractured ends overlap completely, but remain in contact (Fig. 194), the union is secured by a large mass of ensheathing callus, whilst the medullary cavity of each fragment is closed by a plate of internal callus.

If the fractured ends overlap and are kept from contact by the interposition of muscular tissue, union rarely takes place, and an ununited fracture results. The same occurs if the fragments are widely separated, as in the patella.

Where comminution has occurred, the splintered fragments are matted together by an abundant formation of granulation tissue, which is subsequently transformed into callus.

The soft tissues around—muscles, tendons, etc.—are repaired in the usual way, but, owing to the infiltration of the parts with blood and their laceration, the muscles become matted together and often lose their power of independent movement; tendons may become adherent to their sheaths and surrounding structures; nerves and veins may be compressed in the cicatricial tissue, so that the functional result may be most disappointing.

The removal of the clot and the formation of granulation tissue usually take about a week or ten days, and new bone formation commences about the end of the first week. By the third or fifth week, according to the size and vascularity of the bone and the recuperative power of the individual, the fracture will be consolidated, but in the lower limb it is often eight weeks before the patient can bear any weight upon it. Months may, however, pass before the final stage of complete repair is attained.

In conclusion, one must allude to the fact that a sarcoma sometimes develops at the site of fracture within a comparatively short time of the accident.

The **Treatment** of a simple fracture is always to be considered as a task of some difficulty, inasmuch as it involves not only the union of the bony fragments, but also the complete restoration of the limb to functional utility, and that without deformity or unnecessary delay.

First Aid.—In moving the patient from the spot where the accident happened, it is necessary to secure the limb temporarily in as good a position as possible; splints have often to be improvised from sticks, umbrellas, newspapers, and so forth. In a railway accident the splintered débris of the carriages may be employed for this purpose, and the upholstery of the seats as padding. A broken leg may also be firmly tied to the other limb, which is thus converted into a temporary splint.

The **Local Treatment** consists, first, in *setting* the limb, *i.e.*, in reducing the deformity, and replacing the fractured ends in a normal position; then in *fixing* the fragments and limb so as to prevent a recurrence of the deformity; and, finally, in using such further means as massage and manipulation in order to secure the ultimate functional usefulness of the limb.

Reduction of a fracture is usually accomplished by a combination of traction or extension applied to the lower segment of the limb, with manipulation of the fractured ends, counter-extension being at the same time maintained by an assistant. In some cases it is necessary to relax particular muscles in order to facilitate reduction; thus, in the leg, the calf muscles may be relaxed by flexing the knee, or even by division of the tendo Achillis. Rotation must also be corrected, and shortening reduced to a minimum. It is important that the other limb should be uncovered to serve as a standard of comparison.

The manipulation is painful, and so much muscular spasm is often elicited by it that the setting of the fracture becomes almost impossible without an anæsthetic. Reduction should always be accomplished as early as possible, so as to anticipate the stiffness and infiltration which soon develop in the affected parts. At the same time it may be wise to delay a few hours, so as not to give an anæsthetic on a full stomach, or without the previous administration of an enema; but if practicable, a fracture should never be left unreduced for more than twelve hours.

The **Fixation** of the fracture in a good position is provided for by the application of suitable **splints** made of wood, leather, zinc, poroplastic, etc., according to the requisites of the case. If of wood, zinc, or tin, they are usually made according to some general pattern, and fitted to the patient by means of pads. If formed of leather or poroplastic, they can be shaped so as to meet any peculiarities of the part. A paper pattern is first fitted to the opposite limb, and the splint is then cut to the desired shape; it is softened by immersion in hot or cold water, moulded to the part, and allowed to dry. Where leather is employed, the addition of a little vinegar to the water assists in rendering it soft and supple. The edges and corners are finally rounded, and the interior padded with wool or lint. In fractures of the shafts of long bones the joints both above and below the site of fracture should, as far as possible, be immobilized, and the splints must be sufficiently large to encase the part firmly, or if flat, to project a little beyond it, so that the limb may be fixed by the splint, and not the splint by the limb. In all cases careful attention must be given to the padding so as to prevent irritation or sloughing of the skin. In out-patient practice, where the patients are not too careful as to personal cleanliness, it is advisable to pad the splint with some antiseptic material, such as boracic lint, in order to prevent the development of vermin; but it is a wise precaution to shave and purify the limb in all cases, and to dust it over with boric acid and starch. When blebs or blisters have developed, a dry aseptic dressing should first be applied. The splints may often with advantage be fixed to the limb by one or two turns of strapping, and then secured by ordinary calico bandages; these must not be applied too tightly at first, since the swelling of the limb not unfrequently increases afterwards, and undue constriction resulting in gangrene might ensue. Moreover, a limb ensheathed in bandage must never be flexed, but the flexion should always be made beforehand; if this is not attended to, the bandage may cut into the soft tissues, and by compression of the vessels cause gangrene. It is sometimes advisable to bandage the whole of the limb from the fingers or toes upwards, so as to prevent œdema from the pressure of the apparatus obstructing the venous return. The patient should always be seen on the day following the application of the splints, and the condition of the fingers or toes carefully examined; if they look at all blue, or feel numb and cold, the bandages must be slightly relaxed.

It is also desirable that a radiogram be taken after the application of the splints, so that the actual position of the fragments can be estimated. If it is found to be unsatisfactory, a further attempt should be made to improve it, and failing that the question of operation should be raised.

Various forms of **Fixed Apparatus** are used in the treatment of fractures, especially in children. The materials most commonly employed are starch, water-glass, and plaster of Paris.

The *starch* bandage is utilized only in cases where great strength and rigidity are not required. The limb is carefully padded with cotton wool, and over this are applied thin strips of cardboard soaked in starch so as to fit the limb. These are firmly secured by a bandage, the meshes of which are well impregnated with a starch solution, and over all may be placed another bandage, the under surface of which is also rubbed with starch. When this dries, it produces a firm mass, sufficient to immobilize the limb. Should it become loose, it can easily be readjusted by slitting up and paring away a portion on one or both sides.

The *water-glass bandage* is applied by first swathing the limb with a padding of cotton wool, or bandaging it with boracic lint; around this a coarse canvas bandage is applied, soaked in a solution of silicate of soda of the consistency of treacle; several thicknesses of the bandage are required in order to give it the necessary strength. This material is light, easily applied, and makes very little mess, but is slow in drying, taking fully twenty-four hours to become firm.

Plaster of Paris, though rather messy and increasing considerably the weight of the limb, is one of the best means of securing prolonged immobilization. (*a*) The dried plaster may be rubbed into a coarse canvas bandage, which prior to use is soaked for a few minutes in cold water, to which a little salt or alum is added in order to hasten its setting; it is then wound round the limb, which has been previously enswathed in boric lint or wool, and on the exterior of this fresh plaster of the consistency of cream is applied. To make this cream of the right strength the dried powder is cast in spoonfuls into a bowl of cold water, or a weak solution of alum, until it no longer sinks immediately, but remains floating on the surface. The mixture is then stirred with an iron spoon, and is ready for use. When the casing is sufficiently thick, the outer surface is smoothed down with wet hands, or a strip of wet bandage; the date may be advisably marked on it, and the part is slung up to dry. A Gigli saw, smothered with vaseline, may be incorporated in the dressing beneath the plaster, if it is desired to remove it early for the sake of massage, etc.; by this means it is easily cut into two pieces, which can be re-applied daily after the rubbing.

(*b*) Ordinary house-flannel forms the basis of various methods of applying plaster—*e.g.*, Croft's, the Bavarian, etc. In the former, the limb, protected by boric lint or wool, has applied to one side of it one or two thicknesses of flannel, suitably cut to shape, soaked in plaster, and with perhaps a little extra plaster rubbed in; it is fixed to the limb by a muslin bandage. When this is dry, a similar splint is placed on the other side of the limb, and again bandaged on. Division of the bandage down the front permits the removal of the appliance, the bandage over the junction of the two portions behind serving as a hinge. If necessary, thin strips of wood or tin may be incorporated in any of these arrangements, so as to add to their strength.

Early immobilization by means of plaster of Paris, reinforced by strips of wood or tin, has been advocated by certain authorities, constituting the so-called *ambulatory treatment*, and so much confidence have they in it that even fractures of the femur are dealt with in this way within a few days of the accident, and the patient allowed to walk about.

A most valuable adjuvant in the treatment of fractures is **Massage,** advocated so forcibly by the late Professor Lucas-Championnière, whilst in some cases **Early Mobilization** is also desirable. It has long been recognised that after a fracture the limb remains for some considerable period weak and stiff, owing partly to atrophy of muscles, partly to cicatricial adhesions between various divided structures, and in part to contraction of ligaments in neighbouring joints, and that these disabilities increase in direct ratio to the length of time that the limb is kept at rest. It is the object of massage to prevent or obviate these disabilities. In a fracture with displacement through the shaft of a long bone, the part is immobilized by splints for a sufficient time to ensure the non-recurrence of the displacement (say, two or three weeks for most bones, a little longer for the femur). Massage is then commenced, and is conducted methodically day by day, the splints being removed for the purpose and re-applied subsequently; neighbouring joints will also be rubbed, and gentle passive movements undertaken. Possibly some pain may be noticed at first, but it soon disappears, and the patient experiences a sense of comfort. Repair is hastened, but of course the patient must not put any strain on the bone until it is quite consolidated. In fractures near joints or through the articular ends of bones, it is sometimes possible to discard splints entirely, or at any rate to use them only for a short time, steadying the part by some simple contrivance, such as a sling or strapping; massage is commenced within a few days and regularly persisted in. This method of treatment is specially applicable to such injuries as fracture of the anatomical neck of the humerus, the simpler varieties of Colles's or Pott's fracture, and for some fracture-dislocations in the neighbourhood of the elbow. At the same time it is necessary to point out that *active* movements should not be encouraged too early in cases where powerful muscles acting on one of the fragments might overcome the resistance of the callus and reproduce the deformity.

The increasing success of modern aseptic surgery has given considerable impetus to the **Early Operative Treatment** of fractures in order to secure complete fixation and the restoration of function in as short a space of time as possible. At first this plan was only utilized for such bones as the patella or olecranon, but at the present day there is no valid reason for refusing operation in suitable cases. The excellent results following operation in compound fractures, as compared with those gained by the treatment of simple fractures by prolonged immobilization, emphasize this statement. It is often impossible to co-apt accurately the fragments apart from operation, whilst the infiltration of the soft tissues with blood leads to much fibrosis and the formation of many adhesions; moreover, the more lengthy immobilization results in greater atrophy of muscles and stiffness of joints, and hence the commercial value of a working man after a fracture of the thigh or leg is very considerably depreciated, owing partly to persistent deformity, partly to the joints being stiff, whilst the period of convalescence is reckoned by months rather than weeks. Should such a case be operated on, the blood being removed, and the ends of the bone freed from intervening tissues and securely fixed, repair is rapidly effected; the bone retains its normal length; early massage of the muscles and joints above and below becomes practicable, owing to the fixity of the limb, and thus atrophy on the one hand, and stiffness on the other, are avoided.

The actual selection of cases for operation must necessarily vary with the views of the particular surgeon as to the justifiability of the procedure, but most surgeons agree that *the following cases certainly demand operation* : 1. Fractures of small bones or of processes which are not easily retained in position by external appliances, and where healing apart from operation is slow and often defective —*e.g.*, in the patella, olecranon, etc. 2. Fractures involving joints, where fragments are displaced, as when the condyles of the femur or humerus are detached. 3. Fractures of the shafts of long bones which are oblique or spiral, with much longitudinal displacement, and perhaps overlapping, and with the sharp ends of the fragments impacted in muscular or other tissues. Effective reduction in such cases is often difficult even with the tissues laid open, and is practically impossible apart from operation.

As to the *technique*, the incision to expose the bone should be extensive, so as to give plenty of room and allow exit to as much of the extravasated blood as possible. The ends of the fragments are then cleared, brought into correct position with as little handling as possible, and held by suitable forceps, whilst arrangements are made for fixing them. Various contrivances are available, and it is not always easy to determine which to employ. Sometimes it suffices to hold the fragments together by silver wire of appropriate thickness—*e.g.*, for the patella (Fig. 256), or for some oblique fractures of the shafts of long bones (Fig. 195). When the fracture extends through masses of cancellous tissue, it may be possible to fix the fragments by nails, screws (Fig. 250), or ivory pegs driven into them.

For fractures through the shafts of long bones, Lane's plates (Fig. 196) have been largely employed, and often with great benefit, but increasing experience has demonstrated that the results of their employment are not always perfect. (1) They consist of flat metal plates with holes for screws. For a tibia two screws must be introduced both above and below the line of fracture; for a femur three, if not four, must be similarly employed. The use of so many screws involves increasing length of the plates, and a corresponding interference with the nutrition of the bone. (2) The absolute fixity of the fractured ends does not conduce to rapid union; repair is more rapidly and satisfactorily effected when slight movement is possible between the fragments. Thus in the ribs, where fixity is impossible, non-union is unknown. Many cases of delayed union and even of non-union have been observed after "plating" a fracture of the tibia. (3) The actual effect of the screws on the bone in which they are embedded is to cause a rarefactive change, which results in them becoming loose in a comparatively short time. If splints or other retentive apparatus are removed too early, and powerful muscles allowed to act, the plate may be drawn from its attachment and deformity reproduced. Thus a fracture of the upper third of the femur was plated, and the limb was in perfect position at the end of three weeks; without permission or consultation the splints were removed, and in a week's time the powerful adductors had bent the six-screwed plate and detached it from the upper fragment, and had pulled the lower fragment into a position of marked adduction and complete external rotation, necessitating the opening of the perfectly healed wound to remove the plate, and the forcible restoration of the limb to a normal position by manipulation. Especially important is the rarefying effect of the introduction of nails, etc., in the case of fractures near the ends of the long bones in children. Silver wire has less effect in determining bone

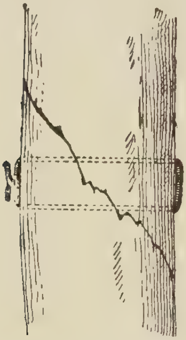


FIG. 195.—FIXATION OF OBLIQUE FRACTURE BY SILVER WIRE LOOP TRAVERSING THE WHOLE THICKNESS OF THE BONE.

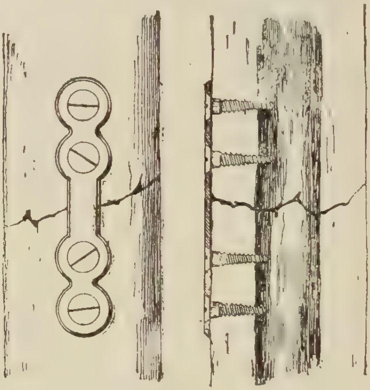


FIG. 196.—LANE'S PLATE APPLIED FOR TRANSVERSE FRACTURE WITH DIAGRAMMATIC LONGITUDINAL SECTION.

atrophy, but in many cases it is wise to avoid metallic sutures entirely, and trust merely to the temporary fixation of fragments by silk or catgut; if the fragments can be kept in position for a few days, it is unlikely that they will be displaced if the limb is suitably fixed in splints or plaster of Paris. (4) It is doubtful whether it is ever wise to employ plates, screws, etc., in compound fractures, especially of superficial bones such as the tibia. If asepsis can be assured, their employment may be justifiable; but where asepsis is uncertain, plates should be avoided.

Complications of Fractures—1. **Implication of a Joint.**—When the fracture extends through the articular cartilage, the joint becomes distended with blood and synovial fluid, but this is subsequently absorbed, and the fissure in the cartilage closed by plastic lymph, which develops into scar tissue. If the fragments are in perfect apposition no harm results, although the joint remains stiff for a little while. If, however, the apposition is imperfect, adhesions of a more serious type develop, and considerable limitation of movement results. It is thus comprehensible that one of the chief indications for the operative treatment of fractures is when they involve joints. In elderly people injuries of this type may result in a chronic traumatic arthritis, particularly in the shoulder or hip. The patient complains of great pain, and the development of osteophytes causes limitation of movement.

2. The same violence that causes the fracture may at the same time produce a **Dislocation** in a neighbouring joint, and particularly in connection with the elbow and shoulder. Treatment should always be undertaken as soon as possible. Should the fracture involve or be close to the articular end of the bone, an attempt should be made to reduce the deformity by manipulation under an anæsthetic; failing this, or if the deformity recurs, open operation should be undertaken if the conditions as to surgical cleanliness permit. In most cases the dislocation is reduced after removing the extravasated blood, and the fracture fixed; but sometimes, when the displaced articular fragment is small, it may be better to remove it entirely. When the fracture is further away from the joint, it is sometimes possible to command the fragments by splints, and then the limb may be manipulated in the usual way, and the dislocation reduced under an anæsthetic. Should this fail, the surgeon may either fix the fracture by operation and repeat the attempt to reduce the dislocation, or he may open the joint and perform an open reduction. The exact method adopted must necessarily vary with the particular condition present. Should immediate treatment be impracticable, the limb should be fixed in splints so as to allow union of the fracture, and at a later date the unreduced dislocation should be treated.

3. The **Main Artery** may be compressed, contused, punctured, or ruptured, giving rise to thrombosis, aneurism, or hæmorrhage. In the former case dry gangrene may result if the terminal vessels are unhealthy; in the latter moist gangrene may be produced by the

pressure of the extravasated blood on the veins. This is most frequently observed in fractures of the lower end of the femur, where the femoral or popliteal artery may be involved. **Treatment** has been discussed elsewhere (p. 120). Here it may only be mentioned that in the case of a ruptured artery operation should, if possible, involve, not only the removal of the blood-clot and the securing of the artery, but also the fixation of the fracture.

4. Laceration of **Veins** results in extravasation of blood, which is not so extensive as when an artery is wounded, since thrombosis occurs more easily; the distal part of the limb may become congested and œdematous, and this may require for its removal firm bandaging and massage. Pulmonary embolus is an occasional sequence of venous thrombosis.

5. The **Nerves** of a limb may be injured at two different periods. (*a*) Immediate injury is due to laceration or rupture, either of the whole trunk, or, as is more common, of the nerve fibrillæ, without loss of continuity of the sheath. (*b*) Secondary symptoms result from inclusion and compression of the nerve in the callus, or from injudicious splint pressure. Irritative symptoms in the shape of neuralgia and muscular spasms are first manifested, followed by paralysis and anæsthesia. This usually occurs three or four weeks after the accident, and may disappear in a month or two, or persist. **Treatment** is always for a time of the expectant type, even when the paralysis is immediate, since total rupture of a nerve is rare, and restoration of function the rule rather than the exception. When, however, the symptoms persist, the parts must be laid open, the nerve freed from adhesions, or exuberant callus removed, and such measures taken as will best secure the nerve from further compression.

Complications arising during Treatment.—(1) If an elderly patient is kept in bed for any length of time in the recumbent posture, *hypostatic pneumonia* is likely to ensue. It occurs most commonly after intracapsular fractures of the cervix femoris, and non-union often results, since the patients must be allowed to get about on crutches at an early date with the limb fixed by a suitable splint. (2) *Bedsores* (p. 120) are very liable to supervene in old people with fractures which need treatment in the recumbent posture. (3) *Crutch palsy* is the result of compression of the brachial nerves between the head of the humerus and the pad of a crutch. It may affect all the nerves of the upper extremity, or may pick out any one of them, and then most commonly the musculo-spiral. It can usually be prevented by the use of spring-padded crutches with cross-pieces for the hands, so as to allow the patient partially to relieve the axillary pressure by supporting the weight of the body by means of the arms. When it has occurred, the use of crutches must be discontinued, and faradism and massage employed to the affected muscles. (4) Occasionally a peculiar induration occurs in the muscles in the neighbourhood of a fracture, resulting in a rapidly developed shortening. It is usually seen in children following fractures of the fore-arm or lower end of the humerus, the flexor muscles being involved, and manifests itself by the fingers becoming flexed and clawed, and by hyper-extension of the wrist. The deformity of the fingers disappears on flexing the wrist, demonstrating thereby that no adhesions of tendons to sheaths are present. It is recognised from the results of a nerve lesion by the absence of sensory or trophic phenomena. This so-called *Volkmann's Ischæmic contraction* has been attributed to splint pressure upon the muscles of the forearm, but it has also been observed when splints have not been employed; probably it is due to a necrobiosis of the muscular tissue due to deprivation of blood resulting from tight bandaging, and this is followed by a spreading myositis fibrosa. Treatment consists in exposing and lengthening the contracted tendons, if massage fails, or in shortening the bone or bones of the limb. The outlook is, however, not very promising. Another muscular complication consists in a deposit of bony tissue therein, a result of a myositis ossificans (p. 420). (5) *Gangrene* may arise from fractures in a variety of ways: (i.) From the immediate effects of the injury, either by its direct action on the tissues, or by causing arterial thrombosis in a limb with atheromatous vessels, or from rupture of the artery with consequent venous thrombosis, owing to the pressure of the extravasation; (ii.) by the supervention of spreading gangrene in a compound fracture; (iii.) from errors in the course of treatment, as by bandaging the limb too tightly, so as to constrict the vessels; or by the bandage becoming unduly tight, owing to the subsequent swelling of the limb; or by flexing a joint after bandaging it, the bandage cutting into the soft tissues; or by the localized pressure of a splint which has been insufficiently padded. Moist gangrene is the type met with in all cases, except when the limb has been previously drained of its fluids by an atheromatous condition of its vessels. (For rules of treatment, see Chapter VII.)

Compound Fractures.

A compound fracture is one in which there is a communication between the external air and the site of injury. It is produced by direct or indirect violence, the solution of continuity of the skin being produced in the former from without, and in the latter by the penetration of a bony fragment from within. It is also sometimes secondary to treatment, the skin over the fracture sloughing as a result of pressure or irritation. The bone may be but little displaced, or may protrude through a small opening in the skin; or the bone may be crushed and comminuted, and a large fleshy wound may be associated with it. In some of the injuries produced by motor-cars, the skin and muscles are violently torn across, and the underlying bone may be pulped, whilst road-dust and dirt are ground into the tissues.

The chief dangers of compound fractures are, firstly, *hæmorrhage*, the blood, instead of collecting within the tissues of the limb, escaping externally if a sufficient opening is present; and, secondly, the advent of *infection*, which may lead to the gravest consequences. Portions of muscle and periosteum, which in a simple fracture would be absorbed or incorporated in the callus, slough; detached fragments of bone necrose, whilst acute osteo-myelitis may develop. Acute suppurative arthritis may result, and secondary hæmorrhage may follow an infective peri-arteritis. Toxæmia to a variable degree is certain to be present, and sometimes pyæmia occurs.

The **Method of Union** of a compound fracture is much the same as that occurring in simple fractures. If the wound can be rendered aseptic, it may be closed by suture, and the fracture is thus converted into a simple one, and repaired accordingly. If, however, suppuration occurs, it is probably attended with a greater or less amount of necrosis, and possibly diffuse inflammation and sloughing of the soft parts; the wound will therefore remain open for a time, varying with the severity of the local phenomena. Healing occurs by granulation, which extends from below upwards, and inasmuch as the deepest part of this granulation tissue is derived from bone and contains osteoblastic elements, it will be transformed into callus, and finally into true osseous tissue. Repair is obviously much slower under these circumstances than in a simple fracture.

In the **Treatment** of compound fractures, the main object is to render the wound aseptic and to give efficient exit to the discharges. For this purpose the patient should in all cases be anæsthetized, the limb shaved and thoroughly purified, and the wound enlarged and thoroughly washed out with some reliable antiseptic. It may be advisable to excise torn and dirty fragments of skin, muscle, and tendon, especially when dirt has been ground into them. Loose fragments of bone are removed, and portions denuded of their periosteum may be taken away lest necrosis should ensue; where fragments retain any considerable connection with the soft parts, they may be left without fear. When a sharp end of one of the fragments is protruding through a small opening in the skin, it is first purified thoroughly before attempting its reduction, and then replaced, after enlarging the wound in the skin, or a portion is sawn off. Hæmorrhage is dealt with in the usual way, and the fragments are placed as nearly as possible in their normal position. It is undesirable to fix them by any metallic mechanical appliance unless they cannot otherwise be kept in position. Where the ends of the bone are much comminuted, the small portions must be arranged in position as well as possible, and no attempt made to wire them. A good-sized drainage-tube is inserted, and, if need be, counter-openings are made; the external wound is closed or not according to circumstances and dressed, and suitable splints are then applied. Under such a régime the majority of cases do well. Immoveable apparatus may be used after a time, windows being left in the plaster casing to allow wounds to be dressed.

In compound fractures which have been attended with complications directed to vessels, nerves, and neighbouring soft parts or joints, the prognosis and course of the case may be considerably modified; treatment suitable to each of these conditions must be adopted.

The question of **Amputation** will necessarily be raised in the more serious cases; but it is unnecessary to add anything here to what has been already stated (p. 244).

Ununited Fractures.

Three varieties of ununited fracture have been described: (1) *Absolute non-union,* when no attempt at repair is made, rarely occurs except when some definite bone disease exists, such as sarcoma or osteo-malacia, or when in a very debilitated patient the limb has not been fixed. (2) *Fibrous Union* consists in the development of a more or less firm mass of connective tissue as the bond of union between the ends of the bones, which are either rounded off and closed by a thin plate of bone or cartilage, or are sometimes atrophic and pointed. (3) A *false joint,* or *pseudarthrosis,* is a condition in which the ends of the fragments are covered either by bone or cartilage, and more or less altered in shape, so as to form a shallow ball-and-socket joint, the capsule being represented by the surrounding fibrous tissue, and the synovial cavity by an adventitious bursa, which results from the friction of the two ends (Fig. 197).

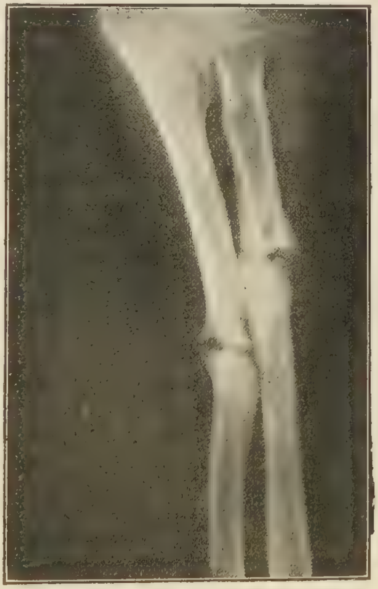


Fig. 917.—Radiogram of Ununited Fracture of the Bones of the Fore-arm. (Dr. Knox.)

The most common situations for ununited fractures are projecting processes of bone to which powerful muscles are attached, such as the patella, olecranon, coracoid process, posterior half of the os calcis, etc.; whilst in long bones the middle of the shaft of the humerus and the upper and lower thirds of the femur are the favourite sites.

Causes.—(1) Want of apposition of the bony ends, owing to muscular action—*e.g.*, in the patella, when the two fragments are widely separated, or in the femur, where they may overlap; (2) the interposition of muscular or aponeurotic tissue, or detached fragments of compact bone; (3) want of rest, one of the most common causes, as in the middle of the shaft of the humerus, where, unless the elbow is well supported, complete immobility cannot be obtained, and non-union is likely to result; (4) defective blood-supply to one or both fragments, as by injury to the nutrient artery, or as in intracapsular fracture of the cervix femoris, where the only source of supply to the upper fragment is a small twig derived from the obturator artery running along the ligamentum teres; (5) local affections of the bone, such as malignant tumours, or the undue pressure of pads upon the newly-formed callus; (6) general bone disease, as osteo-malacia; and (7) general constitutional weakness or debility, sometimes due to definite diseases, such as scurvy or severe syphilis, sometimes to general asthenia or alcoholism. It has been proved that senility, pregnancy, and the cancerous cachexia do not, as used formerly to be stated, predispose to this condition.

The **Signs** of an ununited fracture are usually obvious, mobility between the fragments being easily obtained in some directions, though perhaps not in all; of course crepitus is absent.

The **Prognosis** is fairly good if suitable treatment is adopted, and the local or general conditions do not prohibit reunion. Even operation is not always successful, especially if the soft parts have to be extensively interfered with in order to secure reposition of the fragments; in children under such circumstances the outlook is poor, the ends of the bone becoming atrophic, rounded, and covered by cartilage; in such the final resource is not unfrequently amputation.

Treatment.—(1) If in good position, the parts should be refixed, and a course of passive venous congestion carried out. A Bier's elastic bandage is applied to the limb above the fracture for three or four hours daily. Excellent results often follow. At the same time the general health is improved by a stay at the seaside or the administration of tonics. (2) Failing this, operative measures must be undertaken. If the bone is tolerably superficial, and the ends not very far apart, they should be exposed, sawn into shape, fitted together (preferably by a dove-tailing process), and secured by stout silver wire, plates, screws, or pegs. If, however, the bones are deeply placed, so that it is difficult to expose the ends and fit them together, it may be wiser to leave them in their bad position, and fix them by the insertion of screws or ivory pegs. Thus, in the upper end of the femur non-union is usually associated with overlapping of the ends of the bone to a considerable extent. To expose and fit these together would necessitate a very extensive dissection; it may be desirable in such cases merely to cut down in front upon the upper anterior fragment, drill two holes in different directions through both fragments, and into these insert suitable pegs or screws. Two holes should always be employed, to prevent slipping of the fragments during the necessary manipulations; whilst one drill is removed for the insertion of the peg, the other holds the bone steady. Their presence causes the formation of a large amount of callus, and by this means the fracture is consolidated. (3) When there is loss of substance between the bone ends and other operative measures fail, various methods of *bone grafting* may be employed. Thus, in an ununited fracture of the tibia in a child it may be possible to secure continuity of the bone by the employment of a graft cut from the other sound tibia, or consisting of a portion of the sound fibula.

Vicious Union (Fig. 198) of fractures results either from imperfect adjustment of the ends of the bone, or from the parts not being kept at rest, and hence becoming subsequently displaced. Various kinds of deformity and disfigurement, accompanied or not by loss of function, may result from this accident, and if these are serious, means must be taken to remedy matters. If observed early, when the callus is not too consolidated, it is not difficult forcibly to readjust the parts by manipulation under an anæsthetic, if necessary, refracturing the bone. In some cases powerful mechanical appliances, or osteoclasts, are employed for this purpose, but care must be exercised not to damage unduly the soft parts. The *open* method is certainly preferable, cutting down on the bone, redividing it, removing redundant callus, and fixing the fragments by silver wire, pegs, or screws.

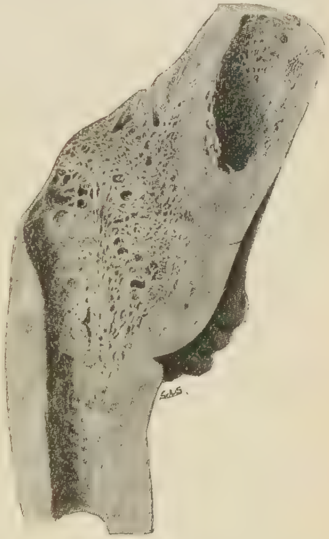


FIG. 198.—VICIOUS UNION WITH MARKED DEFORMITY AFTER FRACTURE OF FEMUR. (KING'S COLLEGE HOSPITAL MUSEUM.)

Disunited Fracture is the term applied to a rare condition, in which a fracture which had been firmly united becomes separated again. It is only met with when the individual develops some extremely debilitating disease, such as scurvy, and may be recovered from under suitable treatment directed to the cause, and by fixation of the parts.

Special Fractures.

Bones of the Face.—The **Nasal** bones are broken as a result of direct violence—by the fist, a cricket-ball, stick, etc. The fracture is generally transverse, and situated just above their free margins; occasionally, when greater force is used, it occurs close to the root of the nose, and may then be associated with fracture of the frontal bone or base of the skull. In young people the cartilages alone may be separated. There is usually considerable deformity from depression or lateral displacement of the fragments, although it may at first be masked by the amount of bruising. Severe epistaxis, surgical emphysema, and cerebral symptoms, are sometimes met with as complications The fracture very readily becomes consolidated, and the deformity is thus often irremediably fixed, unless its presence is determined at once, and suitable treatment adopted. The **Septum** is sometimes broken and depressed, in association with or apart from the above injury. Lateral displacement occurs, causing unilateral nasal obstruction and some amount of obvious deformity. The **Treatment** of these cases consists in immediate replacement of the bones, advisably under an anæsthetic; this may be accomplished by the pressure of some blunt instrument, such as a pair of dressing-forceps, the blades of which, covered with rubber, are introduced within the nostril. A pad of lint or gauze soaked in carbolized oil is, if necessary, inserted to maintain the position, and a gutta-percha or zinc splint moulded to fit the bridge. This dressing should be changed at least every twenty-four hours, and the nose irrigated In old-standing cases, where there is much depression, but little can be done by operation, but subcutaneous injections of paraffin may improve the appearance (p. 814). Lateral displacement can usually be remedied by mechanical appliances or operation.

The **Lachrymal** bone has been broken by direct violence, the fracture usually extending from the nasal bone to the lateral mass of the ethmoid. Interference with the flow of tears and surgical emphysema are the two most marked symptoms.

The **Malar** bone is but rarely broken without the other bones of the face being involved; fracture is almost always associated with damage to the anterior wall of the antrum and considerable depression of the fragments. An attempt should be made to replace the parts by pressure from within the mouth.

The **Zygoma** is fractured by direct violence applied from without; the broken portion may be depressed below the surface, but vertical displacement is limited by the attachment of the masseter below and of the temporal fascia above. Reposition, either by manipulation from within the mouth, or even by operation, is essential in order to prevent interference with the subsequent mobility of the jaw. Perhaps the simplest plan to adopt is to encircle the zygoma subcutaneously with a loop of silver wire and drag it up to its natural level.

The **Superior Maxilla** is invariably broken as a result of direct injury, such as a blow or gunshot wound; it is almost always compound, and often bilateral. The alveolar portion is either partially or entirely detached, or a transverse fissure, extending as far as the pterygoid processes on each side, may render the whole palate and lower part of the facial skeleton moveable. More frequently all the bones of the face are smashed and comminuted, severe hæmorrhage sometimes resulting from wounds of the terminal branches of the internal maxillary artery. **Treatment** consists in merely keeping the patient quiet and applying cooling lotions; union occurs with great readiness, but is sometimes associated with suppuration and necrosis. The patient must be fed by a tube, and a carefully-fitted dental plate should be applied to a broken alveolus.

The **Inferior Maxilla** is usually fractured by direct violence, applied from in front as by a fall or a 'punch' on the chin; more rarely the force acts from the side, and then the bone may break in the middle line. Most frequently, however, the lesion is a little in front of the mental foramen (Fig. 199), this being a weak spot at the junction of two strong parts, viz., the symphysis menti, and the alveolar process carrying the molar teeth; the bone is further weakened by the long narrow alveolus which lodges the canine tooth. This fracture is occasionally bilateral when great violence has been applied to the symphysis. A solution of continuity sometimes occurs close to the angle behind the molar teeth, whilst the coronoid process and condyle have also been broken, the former only as a result of severe direct force—*e.g.*, a gunshot wound—the latter from either direct or indirect violence.

The **Signs** of fracture are very evident if the lesion is situated anteriorly; but when behind the teeth, diagnosis may be much more difficult. The usual variety is almost always compound, owing to the firm attachment of the muco-periosteum to the alveolar border. Laceration of the gums, the blood-stained saliva soon becoming fœtid, the irregularity in the line of the teeth, some of which are loose, and the easily elicited crepitus, all constitute a typical picture. There is often considerable pain, owing mainly to the tearing of the mucous membrane, but possibly due to implication of the inferior dental nerve. The main trunk, however, generally escapes, owing to the position of the fracture in front of the mental foramen, whilst in those behind there is but little displacement. Smart hæmorrhage sometimes occurs from laceration of the accompanying artery. The posterior fragment is usually raised and displaced outwards, whilst the anterior portion is depressed by the action of the hyoid muscles, and may overlap the other. In a bilateral fracture the loose central fragment is displaced downwards by the causative blow and held in that position by the muscles, whilst the posterior fragments are drawn upwards and outwards by the temporal and masseter muscles. When situated *at the angle* or *in the vertical ramus*, there is such equal muscular support on the two sides that but little displacement results. When the fracture passes *through the neck of the condyle*,

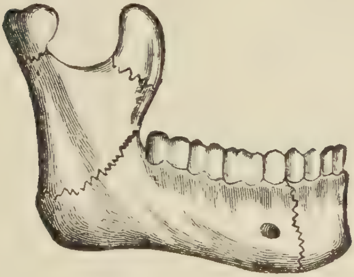


FIG. 199.—LOWER JAW, INDICATING THE MOST COMMON SITES OF FRACTURE.

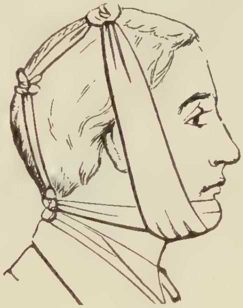


FIG. 200.—APPLICATION OF FOUR-TAILED BANDAGE FOR FRACTURE OF LOWER JAW.

that process is drawn forwards and inwards by the external pterygoid, whilst the body of the bone is freely moveable antero-posteriorly, and displaced towards the fractured side. When the *coronoid process* is detached, it is dragged upwards by the temporal tendon, but no great displacement can occur, owing to the extensive attachment of the tendinous fibres.

Treatment.—Seeing that in the majority of these cases the fracture is compound, the greatest care must be taken to try and keep the mouth clean and free from infection by the use of antiseptic lotions; failure in this direction may result in necrosis of the ends of the fragments, together with suppuration, an abscess perhaps pointing beneath the jaw, whilst pneumonia or even general pyæmia may ensue. The condition of the teeth must be carefully considered, and in any case the co-operation of a skilled dentist is desirable. Teeth that are merely loosened in their sockets may often be left, and will become refixed; but teeth that are quite loose, as also septic roots, should be removed, especially if encroaching on the line of fracture.

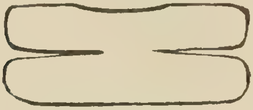


FIG. 201.—LEATHER SPLINT FOR LOWER JAW.

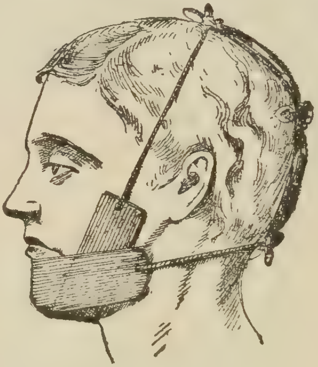


FIG. 202.—LEATHER SPLINT APPLIED.

1. As a temporary measure, and indeed as a permanent appliance in simple cases without much displacement of the fragments and where dental assistance is not to hand, all that is needed is an efficient four-tailed bandage. This is made by taking a piece of calico 4 inches wide and 1 yard in length, and splitting each end into two, leaving about 8 inches undivided, in the centre of which a small longitudinal cut is made for the insertion of the chin. The two lower tails are then drawn up and tied over the vertex, whilst the two upper ends are secured behind the occiput, and then, to prevent slipping, are knotted to the ends of the former (Fig. 200). The bandage is maintained firmly in position for three weeks, the patient being fed through a tube passed between the teeth or through the gap behind the last molar, and all movement of the jaw prohibited. The mouth should be frequently washed out with some antiseptic lotion. Union is usually secured in five weeks.

2. If there is any difficulty in maintaining the parts in good position, a light poroplastic or leather splint may be applied, made in the shape indicated in Fig. 201, the upper portion, which should

reach to the posterior border of the vertical ramus, being folded back, and the lower portion drawn up around the bone. It is lined with lint, and secured by bandages or tapes passed through holes, and tied as shown in Fig. 202.

3. Where there is much displacement, the fragments must be fixed. Wire sutures passed around or between adjacent teeth and tied are distinctly objectionable, causing the teeth to become loose and perhaps diseased. *Hammond's wire splint* is the best apparatus to employ. It consists of a firm wire collar or framework (Fig. 203), which encircles the whole series of teeth in the lower jaw. It is accurately fitted by a dentist, firstly, to a cast of the jaw, subsequently to the jaw itself, and is fixed by several wires passing from one half to the other between the teeth.

4. In cases where a Hammond's splint fails in remedying the displacement, or where the teeth are defective, a Kingsley's apparatus may be used with advantage. It consists of a vulcanite splint fitted over the teeth or alveolar process of the mandible, and extending for a sufficient distance on each side of the fracture to steady the fragments. To the front of this are attached curved metal bars, which extend sideways from the angles of the mouth over the cheeks. It is kept in position by passing a bandage over the bars and under the chin, and secures thereby excellent immobilization of the fragments, even when the mouth is opened.

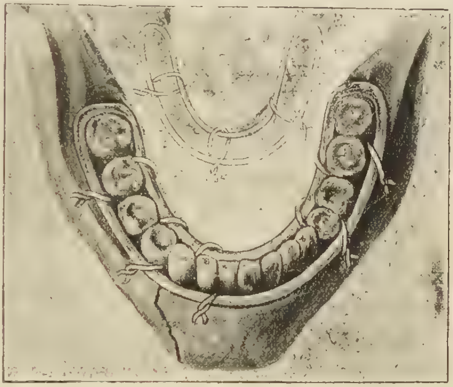


FIG. 203.—HAMMOND'S SPLINT FOR FRACTURE OF LOWER JAW.

5. *Wiring of the fragments* together may be required in a few cases. The wires must be passed either through the bone below the teeth—a task not easy to accomplish without an external wound—or through the empty alveoli of neighbouring teeth, which are extracted for the purpose.

When septic inflammation occurs of such severity as to lead to necrosis, it is best to delay all operative treatment until the sequestrum has been detached, and the parts are more healthy, the patient's mouth in the meantime being frequently cleansed with antiseptic lotions. Wiring of the fragments may then, if necessary, be undertaken with good hope of success.

Fracture of the Hyoid Bone is uncommon, arising usually from direct violence, such as a forcible grasp or the constriction of the neck in hanging. Either the body may be broken, or one of the cornua separated. The symptoms produced are: Pain on attempting to move the tongue, jaw, or neck; a husky voice; and deformity, which can sometimes be detected from without. Occasionally the mucous membrane is perforated, and bleeding into the pharynx may occur, whilst œdema of the glottis may supervene. The fragments should be approximated as well as possible by manipulation between one finger in the mouth and the hand outside, and the neck then fixed by a poroplastic collar.

Fracture of the Ribs may arise in two distinct ways: (1) By direct violence, as by blows or stabs, the fragments being driven inwards, and damage to the underlying pleura, lungs, liver, or diaphragm, being very likely to occur; or (2) much more frequently by indirect violence, as when the chest is compressed between a cart-wheel and the ground, or between a wall and the back of a waggon. The ends of the ribs are then approximated beyond the limits of natural elasticity, and they give way at the most convex part—*i.e.*, near the angle. The viscera may be contused, but less often than in the former class, although hæmothorax from rupture of the parietal pleura is not uncommon. As a rule more than one rib is broken, but the displacement is rarely marked, except in cases due to direct violence, where several ribs have been ‘ staved in.’ The fifth to the eighth ribs are those usually injured, being more prominent and fixed at both ends; the first and second ribs are so well protected by the clavicle as to be seldom broken by direct injury, although great violence from above downwards to the outer end of the clavicle may lead to such an accident: the lower ribs often escape on account of their greater mobility. Elderly women and persons suffering from various mental diseases, such as general paralysis, are specially prone to this fracture.

The **Symptoms** are tolerably obvious, viz., a sensation of something snapping or giving way, a sharp localized catching pain at the site of the injury, increased on deep breathing and coughing, and possibly some local extravasation and swelling. Pain is elicited by a local examination, and also by conjoined pressure upon the sternum and spinal column, whilst the fracture may be evident on palpation, or crepitus detected when the patient coughs or on auscultation. When several ribs are driven in, a marked depression results, but if a single bone is broken in a fat individual, the diagnosis may be extremely obscure. For the clinical history of the pulmonary or pleural complications, see p. 918.

Treatment.—The affected side should be firmly strapped with broad strips of adhesive plaster, so as to limit its movements. The strips, 1½ to 2 inches wide, should extend beyond the middle line, both front and back, and are applied from below upwards, whilst the chest is in a state of forcible expiration, each strip overlapping the preceding one and crossing the direction of the ribs (Fig. 204). A firm woollen bandage should then be applied over all. If the ends of the bone are driven inwards, strapping can rarely be borne, as it tends still further to irritate or compress the lung. Under such circumstances all constriction of the chest must be avoided, the patient being confined to bed with a sandbag between the shoulders, and the arm bound to the side. When the lower ribs are broken, tight applications are generally contra-indicated, since the diaphragm is likely to be irritated, and troublesome hiccough may result. Ribs unite readily, but with a considerable amount of callus, owing to the mobility of the fragments.

Separation of a Costal Cartilage sometimes occurs, giving rise to the same symptoms and requiring the same treatment as a broken rib. Occasionally the cartilage itself may be fractured. In each case the resulting bond of union is osseous.

Fracture of the Sternum is almost always due to direct violence, but is occasionally caused by forcible flexion of the body, and is then generally associated with fracture of the spine. The line of fracture is usually transverse, the bone giving way either between the manubrium and gladiolus or a little below this level. The fragments may remain *in situ* or the upper portion be displaced backwards, the deformity in such cases being very evident, and great dyspnœa resulting. As a late effect, aneurism of the arch of the aorta may occur. **Treatment.**—The patient should be kept in bed with a pillow between the shoulders, and the chest strapped as for fractured ribs. If the patient cannot bear this position, he should be allowed to sit up with the body leaning forwards. Reposition can sometimes be effected by manipulation and extension, but the possible co-existence of a fractured spine must not be overlooked.

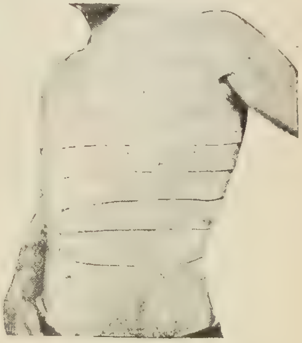


FIG. 204.—METHOD OF STRAPPING BROKEN RIBS.

Fractures of the Upper Extremity.

Fracture of the Clavicle.—No bone in the body, with the exception of the radius, is broken more frequently than the clavicle; this is due to its exposed position and its buttress-like action in keeping out the point of the shoulder, so that every shock to the arm is transmitted through it to the trunk. Hence, although sometimes broken by direct violence, fracture is usually due to force directed to the hand or shoulder, such as a fall from a horse. It is more common in men than in women, and in children is often of a greenstick nature. The bone may yield in four different situations, viz.:

1. **At the Sternal End,** an unusual occurrence, due to direct or indirect violence. The displacement varies with the line of fracture; if transverse, it is slight; but if oblique, and this is most usual,

the outer fragment is drawn downwards and forwards as in the next variety, though to a less degree.

2. **Through the Greater Convexity,** the commonest situation. The bone yields about its centre, or a little external to it, and the line of fracture is slightly oblique, running from before backwards, downwards, and inwards. The displacement is quite characteristic, and is present in any fracture situated between the rhomboid ligament on the inner side and the coraco-clavicular ligaments on the outer, being less marked, however, when the fracture is nearer the extremities than in the centre of this space. The patient gives a history of injury and severe pain, supports the elbow with the other hand, the head being bent over to the affected side to relax the muscles of the neck, and the arm is powerless. The point of the shoulder is less prominent than usual, being approximated to the middle line, and on a lower level than the other, whilst at the seat of fracture the inner fragment projects. This deformity is accounted for by a displacement of the whole outer fragment downwards, forwards, and inwards (Fig. 205); the outer end being, however, more displaced than the inner. This is mainly due to the weight of the arm acting upon the outer fragment when the buttress-like action of the bone is gone; muscular action has but little effect. The position of the inner fragment is probably but little altered, since it is held in place by the rhomboid ligament; the apparent projection of its outer end is mainly due to the depression of the outer fragment.

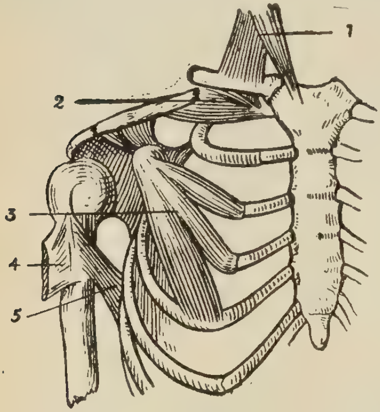


FIG. 205.—FRACTURE OF CLAVICLE THROUGH GREATER CONVEXITY.

1, Sterno-mastoid; 2, subclavius; 3, pectoralis minor; 4, pectoralis major; 5, latissimus dorsi.

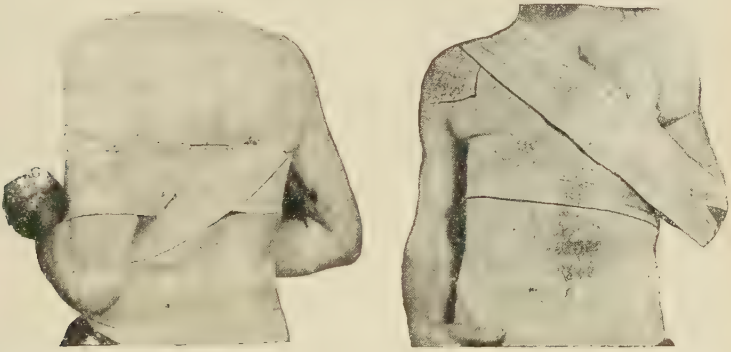
3. **Between the Coraco-clavicular Ligaments,** usually arising from direct violence, and with but little displacement, owing to the tension of the ligaments and to the fact that the periosteum is not torn across. The signs of local trauma and crepitus are, however, present, though not very obvious.

4. **At the Acromial End,** external to the trapezoid ligament, and, again, generally produced by direct violence. The inner fragment retains its position unaltered, but the outer fragment is dragged down by the weight of the arm, and forwards by the action of the muscles, so that it sometimes lies at right angles to the rest of the bone.

Complications arise most frequently in cases produced by direct violence. The subclavian vein may be injured, or the brachial plexus; and even the dome of the pleura and the subjacent lung have been wounded. Gangrene of the arm has been caused by obstruction to the vessels. Great violence has resulted in fracture of the first rib.

Treatment.—Where there is little or no displacement, all that is needed is to immobilize the arm in a sling and to keep the patient quiet. In a greenstick fracture, the deformity must be remedied by manipulation, and the arm subsequently bandaged to the side.

For fractures with displacement many different plans of treatment have been adopted. In order to replace the fragments, the surgeon should stand behind the patient, who is seated, with his knee between the scapulæ; traction is then made upon the shoulders, and the point of the acromion is drawn upwards and backwards. To maintain the fractured ends in apposition the following methods have been recommended: (*a*) The simplest, which can always be applied in emergency cases, is that known as the *three-handkerchief plan.* Two large handkerchiefs, folded double and rolled into bands, are placed vertically, one over each shoulder and under each axilla; each is lightly knotted behind, and the ends firmly tied to the opposite handkerchief across the middle line. By this means the point of the shoulder is kept outwards and backwards. The third handkerchief is now folded crosswise and used as a sling to support the elbow, which is drawn well forwards, the hand being placed over the sound clavicle. If this apparatus is employed permanently, the knots must be examined every few days, especially at first, as the handkerchiefs always stretch a little and require occasional tightening. (*b*) *Sayre's method* is very useful, especially in treating children. A long strip of adhesive plaster, 3½ inches wide or less, according to the size of the patient, is passed round the arm a little below the axilla, as a loop, with the sticky side out, and then around the body with the adhesive side inwards, the arm being drawn well back, and the loop and end secured by stitches (Fig. 206). If this has



FIGS. 206 AND 207.—SAYRE'S METHOD OF STRAPPING FOR FRACTURED CLAVICLE.

been applied firmly, it may now be used as a fulcrum, so that as the elbow is drawn forwards, the point of the shoulder is directed backwards and outwards, and thus the main deformity is overcome. Another strip of a similar width is applied over the elbow (a small hole being cut to receive the point of the olecranon), and by this means the elbow is raised and drawn forwards (Fig. 207) so that the hand can be placed on the opposite shoulder, and the desired position is thus maintained. In children more than one strip of plaster will be needed in order to secure the arm, whilst an additional bandage is also useful. Excellent results follow this plan of treatment. (*c*) In ladies, where even the slightest deformity is undesirable, it is better to confine them to bed for three weeks; the head is kept low without a pillow, and a sandbag placed between the scapulæ, the arm being bandaged to the side.

Union is probably attained in four weeks, but the movements of the arm should be restricted for some time longer. A considerable amount of callus is usually formed, and there is very likely to be some slight persistent deformity.

Fractures of the Scapula.—1. The **Acromion Process** may be broken by direct violence applied to the point of the shoulder. The arm hangs powerless, supported by the other hand, and the shoulder is flattened. The irregularity of the bone can be readily detected, and crepitus can be elicited by raising the elbow and rotating the arm. Occasionally the tip alone is detached, and then the above signs will not be present. **Treatment** consists in raising the elbow, and bandaging the arm to the side.

2. The **Coracoid Process** is rarely fractured, and then only by direct violence. There is but little displacement, on account of the powerful ligaments attached to it, and all the treatment needed is to raise the elbow by a sling and keep the arm to the side.

3. The **Body** of the scapula is broken as a result of considerable direct violence, which is often primarily received by the spine. There is but little displacement when the fracture is comminuted or transverse just below the spine. A longitudinal fracture may, however, result in the inner or vertebral fragment being drawn upwards and outwards in front of the axillary portion by the serratus magnus and levator anguli scapulæ. The diagnosis is sometimes difficult owing to the presence of a large hæmatoma, but can usually be made by detecting crepitus on grasping the bone firmly, and moving one fragment on the other, or by radiography. **Treatment** consists in bandaging the arm to the side, and possibly applying strapping to support the fragments.

4. Fracture of the **Neck** is usually due to great violence directed to the shoulder, but is uncommon. A portion of the articular surface is broken off and displaced downwards in some few cases of dislocated shoulder (Fig. 208, A); or the fracture has been known to run through the anatomical neck (Fig. 208, B), either condition causing some flattening of the shoulder, slight lengthening of the arm, and displacement downwards of the head of the humerus, so that the

appearance somewhat resembles that of a dislocation. **Treatment.**—The arm must be kept to the side and raised.

More commonly, however, the fracture involves the **Surgical Neck** (Fig. 208, C), extending from the suprascapular notch above to just below the origin of the triceps muscle, so that the detached fragment includes the coracoid process. Flattening of the shoulder results, with prominence of the acromion, lengthening of the arm as measured from the acromion to the external condyle, and crepitus on raising and rotating the limb. **Treatment.**—The bone is replaced by pressure in the axilla, if necessary under chloroform, and fixed by an axillary pad or a ∩-shaped leather splint, whilst the arm is kept to the side.

Fractures of the Upper End of the Humerus.—1. Of the **Anatomical Neck,** the so-called 'Intracapsular Fracture' (Fig. 209). This is usually due to blows or falls on the shoulder, less commonly to indirect violence, and occurs more often in elderly people than in the young. The shoulder becomes greatly swollen from effusion of blood; pain on movement is severe, but crepitus may perhaps be felt on rotating the arm; there is usually about half an inch of shortening. In most cases the upper fragment is not totally detached, but remains connected with the rest of the bone by a few shreds of capsule, and thus necrosis is prevented; it is sometimes impacted into the lower fragment, and marked deformity of the head of the bone results, which can be detected occasionally by palpation from the axilla. If it is completely detached, the small upper fragment is often rotated on its own axis, and even dislocated into the axilla. Examination must be conducted with great care lest impaction be disturbed, or any capsular attachments broken through; the routine use of radiography in all serious lesions of the shoulder renders such manipulation less necessary than formerly. Repair takes place mainly from the lower end, and, owing to the difficulty of apposing

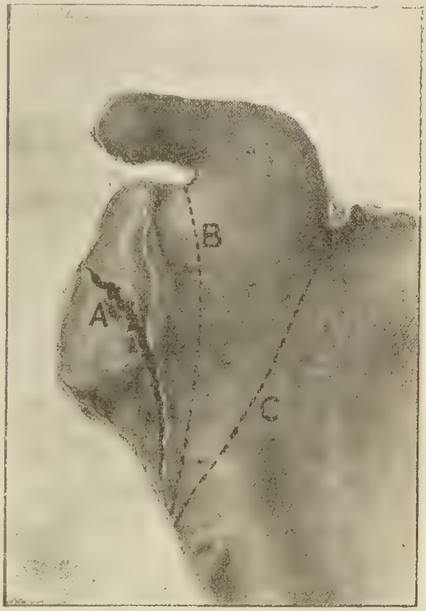


FIG. 208.—FRACTURES OF THE NECK OF THE SCAPULA.

A, Through the glenoid fossa; B, through the anatomical neck; C, through the surgical neck.

and immobilizing the fragments, a considerable mass of callus is usually formed. **Treatment.**—When there is but little displacement, nothing more is required than to raise the elbow and keep the arm to the side by a suitable bandage, though a comfortable sense of support is given by placing a pad in the axilla. Massage is commenced early—about the fourth or fifth day—and passive movements a few days later. In the more serious cases a pad or ∩-shaped splint is placed in the axilla, and retained in position by a soft bandage or handkerchief passing over the top of the shoulder, and tied under the opposite axilla; this assists in raising the arm, which is also supported by an elbow-sling. Finally, a comfortable poroplastic or leather cap is fitted over the shoulder and buckled on. Union generally occurs in about six weeks, but often results in great stiffness, unless massage and manipulation are suitably employed; they must commence, however, a little later than in the simpler cases mentioned above. At first the splints, etc., are restored to position after the daily rubbing, but are gradually discarded, so that by the end of three weeks or so the arm is merely supported by a sling.

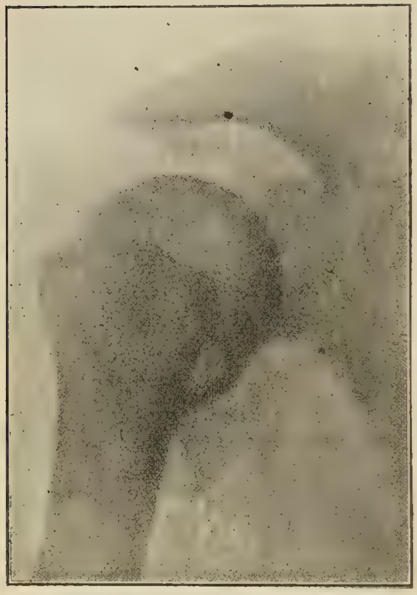


Fig. 209.—Impacted Fracture of the Anatomical Neck of the Humerus.

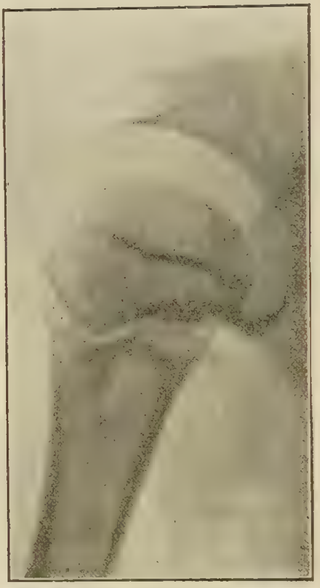


Fig. 210.—Fracture of Surgical Neck of Humerus in a Young Person after Reduction of the Deformity.

If dislocation of the small fragment has occurred, or if radiography indicates that it has been rotated or seriously displaced, the surgeon may advisably raise the question of operation, with a view to removing the fragment entirely.

2. **Fracture of the Surgical Neck,** the 'Extracapsular Fracture' (Fig. 210). The bone yields in this case below the muscles attached to the tuberosities, but above the insertions into the bicipital groove and its margins of the latissimus dorsi, pectoralis major, and teres major. It results from violence applied directly below the point of the shoulder, or from falls on the hand or elbow, and is usually more or less transverse. The displacement of the upper fragment varies somewhat, and is often not very great, but in other cases it is abducted considerably. The lower fragment is drawn inwards by the muscles attached to the bicipital groove, and upwards by the deltoid, coraco-brachialis, biceps, and triceps (Fig. 211). The appearance of the patient is sufficiently characteristic; the head of the bone is still in the glenoid cavity, so that there is no loss of the fulness of the shoulder (Fig. 212, C), although there is a depression just below, unless it is obliterated by the extensive hæmorrhagic effusion. The elbow is directed away from the side, and the axis of the lower fragment is upwards and inwards. Crepitus can be obtained by extending and rotating the arm, which is shortened an inch or more. This fracture is often very painful from pressure of the upper end of the lower fragment against the brachial nerves. If impaction occurs, the signs are much less evident, and, indeed, may be very equivocal; the lower fragment is usually driven into the upper, and only slight shortening or displacement may be present.

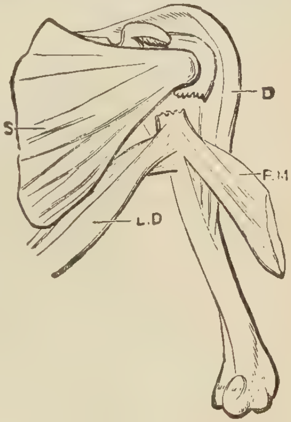


FIG. 211.—FRACTURE OF SURGICAL NECK OF HUMERUS.

S, Subscapularis; L.D., latissimus dorsi; D, deltoid; P.M., pectoralis major.

Complications.—The axillary vessels may be seriously damaged, or more commonly some of the nerves sustain injury, especially the circumflex, which winds round the neck of the bone close to the site of the fracture.

Treatment.—Immobilization of the fragments is absolutely necessary in this fracture. It may be secured in the simpler cases by the application of an axillary pad and a shoulder-cap, whilst the arm is kept to the side, and the hand well supported by a sling. Middeldorpf's triangle (Fig. 214) may be used with advantage in this fracture. When the fracture is oblique and the fragments overlap, the patient must be put to bed, and continuous traction made in an abducted position of the limb. An extension apparatus (p 535) is applied to the arm from the elbow upwards, and a weight of from 5 to 10 pounds attached, the cord passing over a pulley at the side of the bed. Counter-extension is made, if need be, by a sheet passed round the body. Massage is employed from the first in order to assist absorption of the effused blood and to allay muscular spasm. At the end of a fortnight the patient is allowed up with a simple retentive apparatus, but daily massage and movements are maintained for some time. Firm union usually results in four and a half to six weeks, but with the formation of a good deal of callus.

3. **Separation of the Upper Epiphysis** occurs up to the age of eighteen to twenty years, and involves the head and both the tuberosities. The upper end of the shaft is somewhat conical in shape, the apex of the cone fitting into a depression in the middle of the epiphysis (Fig. 213). The lesion usually follows the line of the cartilage; but the displacement is often incomplete, partly from the conical projection hitching against the inner edge of the epiphysis (a doubtful occurrence), but mainly from the persistence of a well-marked periosteal sleeve or bridge on the outer and posterior side. The shaft usually travels forwards, its upper end projecting so as to be felt or even seen beneath the skin an inch or more below the coracoid process; occasionally a well-marked inward displacement is superadded, so that the condition somewhat resembles a subcoracoid dislocation. The presence of the head of the bone in the glenoid cavity should prevent this mistake, whilst the softness of the crepitus distinguishes it from a fracture.

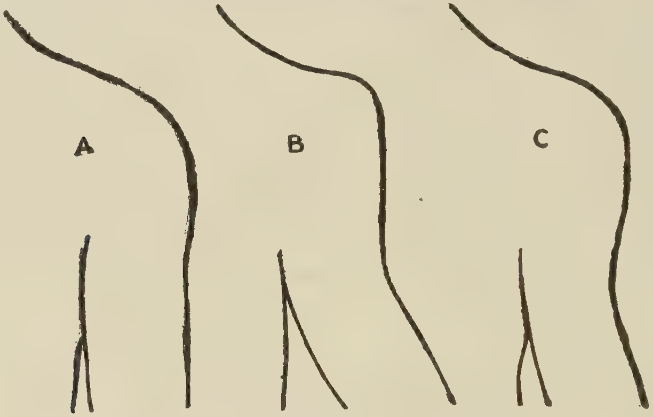


FIG. 212.—OUTLINES OF SHOULDER.

A, Normal shoulder; B, dislocation of shoulder; C, fracture of surgical neck of humerus.

Treatment.—It is most important to reduce this displacement, since otherwise interference with the growth of the limb is almost certain to ensue This may be effected by traction upon the arm under an anæsthetic, assisted perhaps by slight rotary movements or abduction; but should these manœuvres not be successful, operation should be undertaken to restore the parts to their correct position. After reduction the limb is treated as for a fracture of the neck. Should union occur in the displaced position, considerable limitation of movement results from the projecting edge of the diaphysis; this may be improved by cutting down and chiselling it away.

4. The **Great Tuberosity** is occasionally torn off as a result of direct or muscular violence, or as a complication of fracture through the neck. If the whole tuberosity is separated, there is marked deformity, resulting in a great increase in the breadth of the shoulder. The fragment is displaced upwards and backwards by the unopposed action of the supra- and infra-spinatus, whilst the shaft of the humerus is drawn forwards and partially dislocated (or subluxated) by the subscapularis and other muscles. A distinct sulcus is felt between the two bony masses, and if they can be brought together, crepitus is obtained. **Treatment.**—There can be no question that when displacement has occurred, the most efficacious plan is to cut down on the fragment and fix it in position by wire, screw, or peg. This is best effected by cutting through and turning down the deltoid from above. Excellent results follow, if asepsis is maintained Failing operative treatment, the patient must be kept in bed, with the arm elevated and extended, supported by pillows—a most uncomfortable position—until union has occurred.

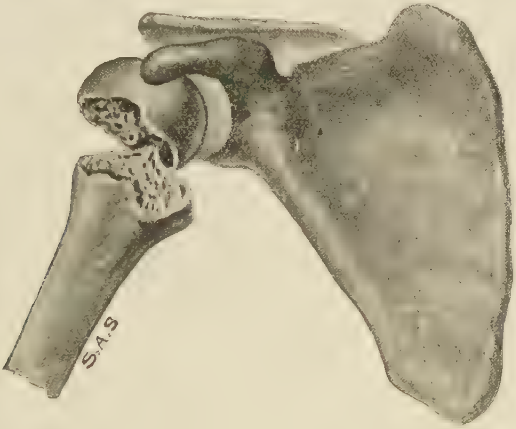


FIG. 213.—SEPARATION OF THE UPPER EPIPHYSIS OF THE HUMERUS.

5. **Fracture of the Upper End of the Humerus combined with Dislocation** of the head of the bone is not a very common accident. The fracture is usually more or less oblique, and passes through the greater tuberosity or involves the surgical neck.

It is usually produced by severe direct violence, such as by a person pitching with great force on the shoulder. The head of the bone is first forced into the axilla through a rent in the capsule, the tendons, attached to the tuberosities being stretched or torn, and, secondly, the violence being unexpended, fracture of the neck of the bone follows. Unless seen early, hæmorrhage and serous effusion make diagnosis difficult, and from time immemorial mistakes have occurred in diagnosis and treatment. Stereoscopic radiography should, where practicable, be used as soon as possible. At the same time the tension of the deltoid and the absence of the head from the glenoid cavity and its presence elsewhere should suffice to guide the surgeon to a correct opinion. If unreduced, the displaced head of the bone may remain loose, or union may occur with much deformity and the production of many adhesions, which may involve the vessels and nerves, and lead to serious after-trouble in the limb.

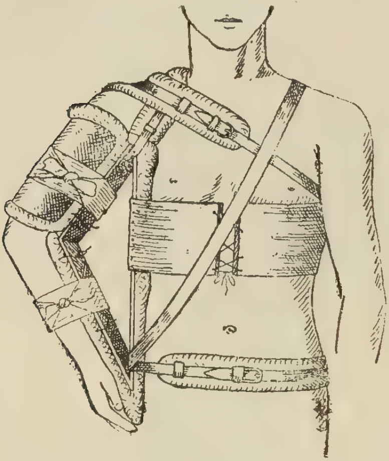


FIG. 214.—MIDDELDORPF'S TRIANGLE FOR FRACTURED HUMERUS.

For the sake of clearness, the bandages, etc., have been represented as much smaller than would be the case in the living subject; a Gooch splint may also with advantage be applied to the fore-arm.

Treatment.*—The reduction of the dislocation is a matter of considerable difficulty, but the head of the bone should, if possible, be manipulated back through the rent in the capsule without delay, whilst steady traction is made upon the shaft of the limb either downwards or at right angles to the trunk. This reposition can hardly be hoped for apart from complete anæsthesia. If successful, the fracture is treated in the usual way, suitable apparatus to maintain end-to-end apposition of the fragments being applied. If, however, reposition is not effected, operative measures should be undertaken. The parts are laid open from the front, the head of the bone is replaced, and the fracture wired or screwed into accurate end-to-end union. Failing that, and especially if any loose fragments due to breaking up the globular head exist, they should be excised. McBurney has devised a special hook, which can be introduced through a hole in the bone so as to exercise traction to facilitate the open reduction of the dislocation or the division of ligaments if excision is required.

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* For an interesting series of radiograms of this condition, see an article by Robert Jones, *British Medical Journal*, June 16, 1906. The subject is also ably dealt with in Bransby Cooper's (1842) edition of Sir Astley Cooper's treatise on 'Dislocations and Fractures of the Joints.'

Fractures of the Shaft of the Humerus may arise from any form of violence, whether direct or indirect, and even from muscular violence, as, *e.g.*, in throwing a cricket-ball. The signs of the injury are very obvious, and most typical. The displacement depends largely on the position of the fracture. If it occurs above the insertion of the deltoid, but below that of the muscles inserted into or around the bicipital groove, the upper fragment is drawn inwards, and the lower upwards and outwards. If, however, it is below the deltoid, the upper fragment is drawn outwards, and the lower upwards and inwards. As the line of fracture approaches the elbow, the displacement tends to become more antero-posterior than lateral, owing to the change in shape of the bone. The most common complication is injury to the musculo-spiral nerve which winds round the shaft close to its centre.

Treatment.—An internal angular splint reaching from the axilla to the wrist must be applied, together with three small lateral splints to fix the fragments, or a piece of Gooch or kettle-holder splint; the limb is kept to the side in the sling. Union is usually complete in five weeks.

Some authorities recommend the use of four short lateral splints, the outer one of which is prolonged upwards to constitute a shoulder-cap, and downwards as an external angular splint. The fore-arm is kept midway between pronation and supination; and the hand points directly forwards, so as not to rotate the lower fragment.

A useful appliance for all fractures of the humerus is the Middeldorpf triangle (Fig. 214). It is carefully padded so that the angles and edges are protected, and applied so that its base is in contact with the body-wall and its obtuse-angled apex in the elbow. It is fixed by a strap or bandage passed from the axillary angle over the same shoulder and under the opposite axilla, as also by a sheet or bandage round the trunk. Pieces of Gooch splinting can be applied to the arm, thus completely immobilizing the humerus, and the fore-arm is also fixed. The fingers are left free, or if there is any swelling they are bandaged. This apparatus is even more efficacious when the patient is standing than when he is recumbent.

It is not at all uncommon to meet with an ununited fracture of the shaft of this bone; this is probably due, not to any anatomical reasons, but simply to the fact that the necessity for fixing and supporting the elbow-joint has not been appreciated, the fore-arm being allowed to hang loose on the false plea of tending to diminish the shortening.

In oblique fractures, or where there is difficulty in securing exact reposition, operation may be undertaken and the fragments fixed by some suitable mechanical appliance. Care must be taken to place the incision so as to avoid the musculo-spiral nerve.

Fractures of the Lower End of the Humerus.—In dealing with any injury in the vicinity of the elbow, it is absolutely essential that the relative position of the bony points, which can there be felt, should be accurately established, and a comparison made with those of the opposite side. Normally four bony prominences can be detected, viz., the two condyles, the olecranon, and the head of the radius. The relation of the olecranon to the condyles varies with the position of the elbow. If the fore-arm is extended, the tip of the olecranon just touches the intercondyloid line, but is placed nearer the inner than the outer condyle, whilst in flexion of the fore-arm it lies below that line. The head of the radius in all positions of the arm is immediately below the outer condyle, and can be felt rotating beneath a dimple in the skin which appears at that spot. When the fore-arm is flexed to a right angle, the tip of the olecranon is a little in front of the posterior surface of the arm, so that a ruler placed along that surface misses the olecranon; this is a useful guide in ascertaining if the bones of the fore-arm have been displaced backwards or forwards, together with or apart from the lower end of the humerus.

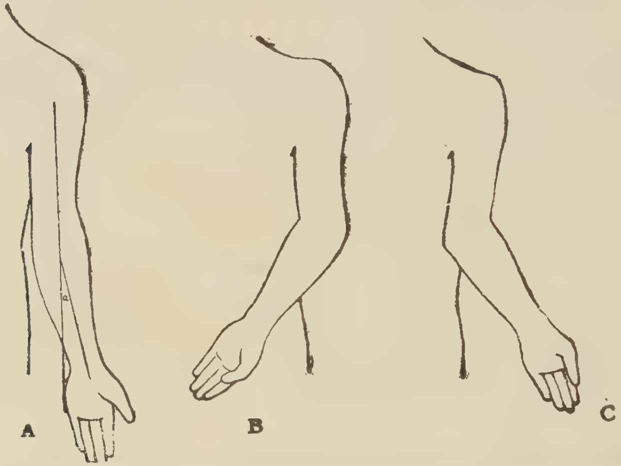

FIG. 215.—OUTLINES OF UPPER EXTREMITY TO SHOW A, NORMAL CARRYING ANGLE ($a = 15°$); B, CUBITUS VARUS; C, CUBITUS VALGUS.

Another important feature depends on the fact that the axis of the fore-arm does not correspond with that of the arm, the former being in a position of slight abduction (about 15°), constituting what is known as the 'carrying angle' (Fig. 215, A). Lateral deviation following fractures in the neighbourhood of the elbow results in modifications of this angle, and if these are allowed to persist, conditions of cubitus varus or valgus (Fig. 215, B, C) ensue, which much interfere with the utility of the limb.

1. **Transverse Supracondyloid Fracture,** involving the shaft about 1 or 2 inches above the joint, is due either to a fall on the hand with the arm bent, when the lower fragment is usually displaced back-

wards, or much less commonly to a fall on or violence directed to the point of the elbow, when the displacement is either forwards or backwards. When the lower fragment is displaced backwards, it is also drawn up by the action of the triceps upon the olecranon, a certain amount of angular as well as vertical deformity being thus produced; when displaced forwards, apparent lengthening of the fore-arm results, with a loss of prominence of the olecranon. The former of these conditions is likely to be mistaken for a dislocation of both bones backwards at the elbow (*cf.* Fig. 216, A and B), but may be recognised by the following facts: (*a*) The relative position of the bony points at the elbow is unimpaired; in a dislocation they are necessarily disturbed. (*b*) The length of the arm measured from the deltoid tubercle which can be easily felt at the back of the acromion to the outer condyle is diminished in a fracture, but remains unaltered in a dislocation. On the other hand, the length of the fore-arm, as measured from the external condyle to the styloid process of the radius, is shortened in a dislocation, but remains unaltered in a fracture. (*c*) The forward projection of the lower end of the upper fragment is felt above the crease of the joint, whilst in a dislocation it corresponds with it. (*d*) The deformity is easily reduced with crepitus, but readily reappears; in a dislocation the bones are replaced with difficulty, but after replacement they usually remain in position. Lateral deviation sometimes occurs, and the restoration of the normal ' carrying angle ' must always be aimed at. It may be difficult and at times almost impossible to recognise this condition at once, apart from radiography, owing to the amount of swelling and ecchymosis present; the application of a cooling lotion for a few days will so reduce this as to permit a thorough examination, but the

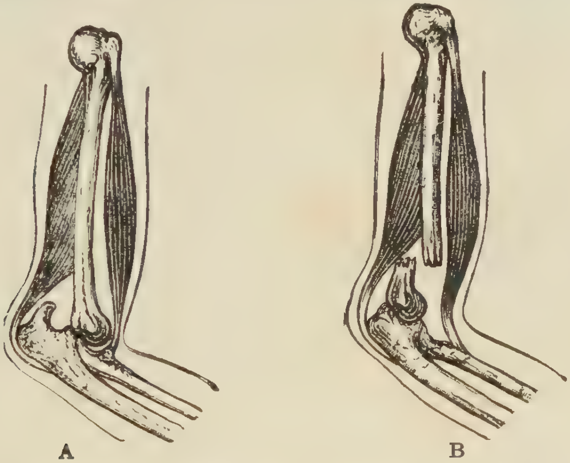

Fig. 216.—Fracture of Lower End of Humerus (B) compared with Dislocation of Radius and Ulna Backwards at Elbow (A). (Tillmanns.)

delay may be fraught with serious consequences, and in all doubtful cases radiography must be employed at once.

Much care is needed in the **Treatment** of these cases in order to prevent ankylosis or deformity, and the stereotyped application of an internal angular splint is by no means desirable. To correct the backward deformity the elbow must be placed in a position of full flexion, whilst the fore-arm is completely supinated. It usually suffices to maintain this position by means of bandages or strapping without splints, a layer of aseptic wool covered with dusting powder being placed between the adjacent surfaces of the arm and fore-arm. In case of necessity, the best splint to use is a moulded gutter-shaped posterior splint reaching well above and below the elbow, whilst a shorter anterior splint reaches down to the bend of the joint. In these fractures the elbow-joint is not as a rule involved, and therefore passive movement is not commenced too early for fear of deformity, owing to yielding of the callus. At the same time, it must not be delayed too long, as if the olecranon and coronoid fossæ are involved, they become filled by callus, and if this is allowed to consolidate, the movements of the arm will be subsequently limited. In displacements of the lower fragment forwards an anterior angular splint should be employed, and possibly a short posterior one in addition.

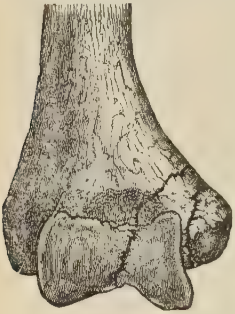
FIG. 217.— FRACTURES OF INTERNAL CONDYLE AND EPICONDYLE OF HUMERUS. (TILLMANNS.)

2. **T- or Y-shaped Fracture** usually occurs as a result of direct injury. The T-shaped variety is a condition in which a longitudinal fissure extends into the joint through the centre of the lower fragment of a supracondyloid fracture ; in a Y-shaped fracture the fissure starts at the articular line and bifurcates above so as to detach both condyles. Sometimes the fragments are not completely detached, and then there will be much bruising and pain, but no crepitus; at other times the condyles are separated completely and will move on each other with crepitus, the elbow being increased in breadth. Great swelling and ecchymosis are rapidly developed, and diagnosis is often difficult. If there is no separation of the fragments, treatment as for the transverse supracondyloid fracture suffices; but when they are completely detached, it is often wise to operate so as to remove the blood and enable the fragments to be manipulated into position and fixed there.

Excessive violence may lead to comminution of the lower fragment, and then it may be advisable completely to remove it.

3. Fracture of the **Condyles** usually results from direct injury, though the outer is sometimes broken by indirect violence, such as a fall on the hand, since the laxity of the elbow-joint on this side allows considerable mobility between the radial head and the capitellum of

the humerus. Fracture of the **external condyle** (Fig. 218) always involves the elbow-joint, and is more common than that of the inner. The line of fracture runs from the condyloid ridge downwards and inwards so as to separate the capitellum, or even encroach upon the trochlear surface. The fragment is rotated forwards, and can be felt to move independently with crepitus, which may also be produced by rotation of the hand and radius. The accident is associated with much pain and ecchymosis. Fracture of the **internal condyle** may be intra- or extra-capsular. The *extra-articular* variety (Fig. 217) consists of a mere displacement of the tip of the condyle (or epicondyle), and in young people is probably a separation of the epiphysis, which remains distinct from the shaft till the age of eighteen or nineteen years. The small fragment is drawn a little downwards by the muscles attached to it, and may be associated with injury of the ulnar nerve. The *intra-*

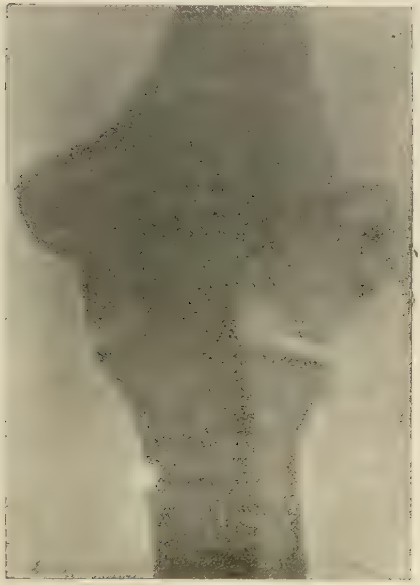

FIG. 218.—FRACTURE OF THE EXTERNAL CONDYLE.

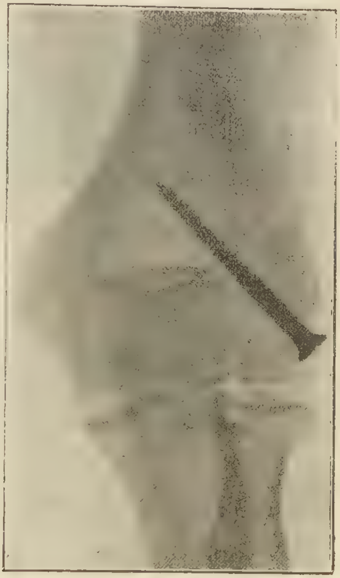

FIG. 219.—THE SAME FRACTURE AFTER OPERATION.

Fig. 218 is a good illustration of the deceptive appearance which may result from radiography. It appears as if the condyloid fragment were displaced outwards; as a matter of fact, it was merely rotated forwards, but as the radiogram was taken slightly from the inner side, the shadow of the fragment overlapped that of the shaft. The patient was a girl of fifteen years, who fell on the elbow from her bicycle.

articular form is the more common, and extends from the condyloid ridge to the trochlear surface, implicating the coronoid and olecranon fossæ. The fragment is displaced a little upwards and backwards, the ulna usually accompanying it, so that on extending the elbow the olecranon appears unduly prominent, the lower end of the humerus projects anteriorly, and the fore-arm is slightly adducted (cubitus varus). The ulnar nerve may also be injured in this case.

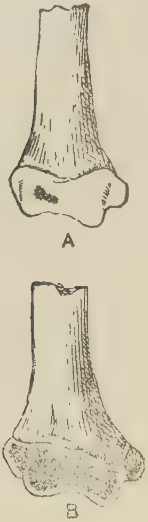

FIG. 220.—A AND B, LOWER END OF THE HUMERUS AT THREE YEARS AND FIFTEEN YEARS OF AGE. (SEMI-DIAGRAMMATIC; AFTER QUAIN'S ANATOMY.')

In A there is only one centre of ossification; in B all the centres in the lower epiphysis have joined together with the exception of that for the internal condyle.

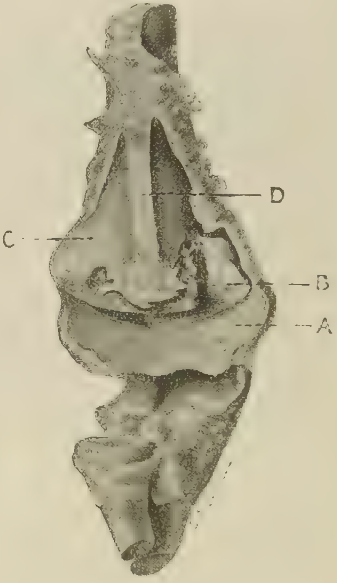

FIG. 221.—SEPARATION OF THE LOWER EPIPHYSIS OF THE HUMERUS IN AN INFANT UNDER THREE YEARS. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

A, Epiphysis, including both condyles; B, small portion of the diaphysis detached with epiphysis; C, diaphysis; D, loose periosteal bridge.

Treatment.—Flexion of the fore-arm will sometimes suffice to restore the fragment to its normal position; but this must be demonstrated by radiography. The limb under such circumstances is placed in an angular splint, and massage and passive movements are started early. Failing reposition by flexion, operation must be undertaken, and the fragment secured in position by wire or screw (Fig. 219).

4. **Separation of the Lower Epiphysis of the Humerus** is a very common accident in children. At birth and for some years after-

wards the epiphysis consists of a single mass of cartilage, including the two condyles as well as the articular surface, and these are all involved in any separation, together possibly with a fragment of the diaphysis (Fig. 221). As, however, growth and ossification proceed, the shaft encroaches rapidly upon the inner portion of the epiphysis, so that the epiphyseal line becomes almost rectangular (Fig. 220, B), the internal condyle being isolated from the rest of the epiphysis. As a result of this, separation of the epiphysis after puberty does not include the internal condyle; the lesion at this period is situated relatively much nearer the joint than in infants, and consequently is more likely to be followed by impairment of movement. The displacement is generally backwards (Fig. 222), with some amount of lateral displacement or deviation (Fig. 223). **Treatment.** —Reduction can usually be accomplished by flexion with some amount of traction. In young children it is best to avoid splints, and merely to trust to keeping the limb in a state of full flexion, the hand being well supinated. Where there is much swelling from hæmorrhage, it may not be possible to gain complete flexion at once, but as the swelling subsides it can be gradually increased. In a

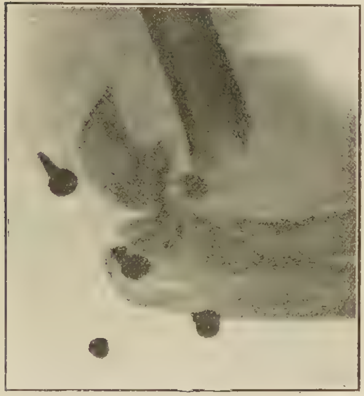

FIG. 222.—SEPARATION OF LOWER EPIPHYSIS AND A PORTION OF THE DIAPHYSIS IN A CHILD OF TWELVE YEARS.

The radiogram is taken from the side. The displacement is backwards. The dark black spots represent tin-tacks in the wooden splint on which the arm was resting. The dark area around the end of the bone represents the sub-periosteal effusion of blood.

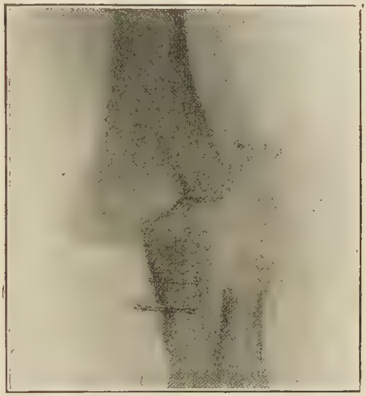

FIG. 223.—SEPARATION OF THE LOWER EPIPHYSIS OF THE HUMERUS, WITH DISPLACEMENT OUTWARDS, IN A YOUNG PERSON A LITTLE OVER THE AGE OF PUBERTY

The outer condyle has been broken off, as well as the epiphysis, and displaced upwards and outwards; above this fragment is seen a shadow caused by the stripping up of the periosteum. The ulna and radius accompany the lower epiphysis of the humerus outwards.

few cases it may be desirable to make an incision through the periosteum on one or both sides of the bone so as to allow the blood to escape, and enable the epiphysis to be manipulated into position; but even then it is better not to attempt fixation by nails, screws, or wire, but merely to trust to the flexion. Massage and passive movements should commence about the eighth day. Parents should be warned from the first that a perfect restoration of function cannot be guaranteed, as the fossæ at the lower end of the humerus are encroached on and are liable to be filled up with bone, and hence complete flexion or extension may be hindered, whilst the involvement of the epiphysis may impair the growth of the limb and lead to a condition of cubitus varus or valgus.

Fractures of the Ulna.—1. The **Olecranon** is frequently broken by direct violence, the patient falling on the bent elbow, but occasionally by muscular action. The line of fracture usually runs through the base of the process at its attachment to the shaft, and is for the most part transverse. Should the tendinous and periosteal coverings of the bone remain intact, there is but little separation; but if the fracture is complete, the detached fragment is drawn up by the triceps and tilted backwards (Fig. 224), whilst the bones of the fore-arm are subluxated forwards. Great swelling in and around the joint comes on early; on examination, the detached fragment can be readily distinguished, and between it and the shaft a sulcus, which increases on flexing and diminishes on extending the fore-arm. If the fragments are not brought accurately into apposition, fibrous union occurs, and although the new cicatricial tissue may stretch considerably, a useful elbow sometimes results; in some cases the fragment is drawn up and fixed to the humerus, and a false joint is developed below it. If, however, the fragments are brought in contact, bony union follows, though even then some impairment of function may result from the formation of adhesions. In all cases the ulnar nerve is exposed to injury, though it is rarely affected.

Treatment.—The arm must be kept fully extended on a suitable splint, and an effort made to bring the fragment into apposition with the end of the ulna by a pad and strapping. Gentle passive movements and massage are commenced at the end of ten days or a fortnight, but active movements should be deferred for another fortnight. When, however, the olecranon has been completely separated, the most satisfactory plan consists in laying the parts open, freeing the joint of blood-clot, removing shreds of tendon which may be placed between the fragments, and then wiring them together, the wire just extending down to the articular cartilage (Fig. 225). Passive movements may usually be started in ten days, and active after a fortnight. A similar plan should be adopted in all compound cases, and in those where loose fibrous union has occurred with a resulting weak and relaxed elbow; in the latter instance the new fibrous tissue must be entirely dissected away and the bony surfaces freshened.

2. The **Coronoid Process** is so deeply placed and so well protected that fractures must necessarily be very uncommon, except as an accompaniment of dislocation of the ulna backwards. The signs relied on in making a diagnosis are that reduction of the dislocation is easier than usual and associated with crepitus, and that the deformity is likely to recur. The **Treatment** consists in apposing the bony surfaces, if possible, by flexing the fore-arm. Bony union is, however, less important than a freely moveable elbow, and therefore passive movement is commenced early.

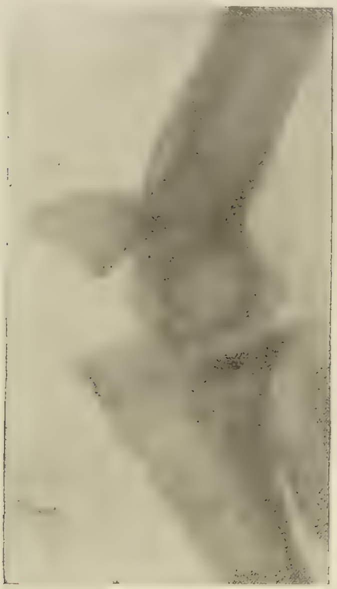

Fig. 224.—Fracture of Olecranon before Operation.

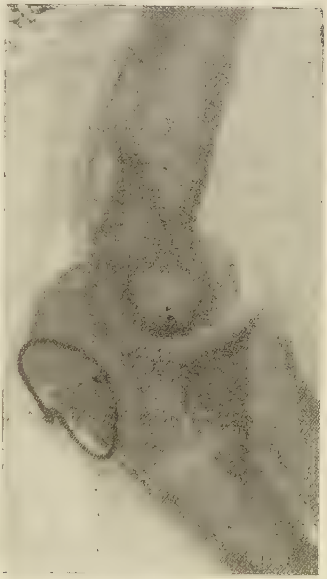

Fig. 225.—Fracture of Olecranon Two Weeks after Operation.

3. The **Shaft of the Ulna** is often fractured by itself as a result of direct violence, to which its exposed position renders it peculiarly liable. Fracture also occurs as a complication of several of the forms of dislocation of the radius alone. The superficial position of the posterior border renders examination of the bone easy; if displacement or a breach of substance occurs, it is readily detected, but when merely a fissure exists, it is not so easy to make out. The constant pain referred to one spot, the slight mobility, and possibly crepitus, indicate the character of the lesion. No longitudinal displacement can occur if the radius remains intact, and under such circumstances the only deformity consists in a slight drawing forwards of the upper fragment by the brachialis anticus,

whilst the lower fragment is approximated to the radius by the pronator quadratus. **Treatment.**—The arm is placed midway between pronation and supination, the deformity corrected, and the limb kept at rest between anterior and posterior splints, or in plaster of Paris.

4. The **Styloid Process** may be detached by direct violence, or as a complication of fracture of the lower end of the radius. The displacement may be considerable and very evident, being governed by the direction of the violence. **Treatment** consists in replacing the fragment by manipulation, and fixing it by adhesive plaster; an anterior splint is applied with the hand adducted. Fibrous union usually results.

Fractures of the Radius.—1. The **Head of the Radius** may be broken alone, but more usually such an accident is associated with other injuries to the elbow, as, for instance, fracture of the outer condyle or some form of dislocation. The line of fracture may be transverse or vertical, and the displacement is slight if the orbicular ligament remains intact. In complete separation the head is immoveable, and crepitus is produced when the arm is rotated; bony union usually follows, with more or less impairment of function, but sometimes the head, or a portion of it, remains detached as a loose body; in the latter case the small fragment may get between the articular ends from time to time and lock the joint. **Treatment.**—Radiography will indicate the exact nature of the injury, and as a rule removal of the loose fragment and of the remainder of the head, if it be small, is the best plan to adopt. The incision is of course a posterior one. The limb is subsequently kept at rest for a short time midway between pronation and supination, and early passive movement instituted. Excision of the head may also be required in old-standing cases for limitation of movement, due to excessive formation of callus.

2. The **Neck,** *i.e.*, the portion between the orbicular ligament and the biceps tuberosity, is occasionally broken. The lower fragment is drawn upwards and forwards by the biceps, causing a bony projection on the front of the elbow, especially evident on attempting to flex the joint, whilst the fore-arm is pronated with loss of the power of rotation, and the head of the bone does not accompany the shaft on rotating it passively. **Treatment.**—The arm is flexed to relax the biceps and supinated, and the limb placed on a posterior angular splint, with a pad over the front of the lower fragment. Passive movement should not be commenced too early, as the lesion is extra-articular, and the biceps may produce permanent deformity if allowed to act upon unconsolidated callus.

3. The **Shaft** of the radius is not unfrequently broken by direct violence or more rarely by falls on the palm; the latter accident, however, rarely causes fracture except at the lower end. A *Chauffeur's fracture* of this bone has also been described. It involves the lower end of the radius, and results from a jerk backwards of the starting handle of the car due to premature ignition. The lesion is

located either transversely through the articular surface, or in the shaft a little above the level of an ordinary Colles's fracture, and sometimes well-marked displacement is present.

There is usually little difficulty in diagnosing a fractured radius; the chief signs are localized pain and loss of power of active rotation, whilst passive rotary movements are accompanied by crepitus, the head of the bone and upper fragment remaining immobile below the outer condyle, unless impaction is present. The *displacement* is somewhat characteristic. If the fracture is situated *above the insertion of the pronator teres*, the upper fragment is flexed and fully supinated by the action of the biceps and supinator brevis, whilst the lower fragment is drawn towards the ulna and fully pronated by the unopposed action of the two pronator muscles. **Treatment.**—Inasmuch as it is scarcely possible to command the small upper fragment, the lower must be brought into apposition with it by fully supinating the fore-arm and hand after flexing the elbow, and applying a posterior splint, the patient being preferably kept in bed for a time and the arm laid on pillows. It may afterwards be supported in a hollow leather splint carried across the body, and with the palm directed upwards.

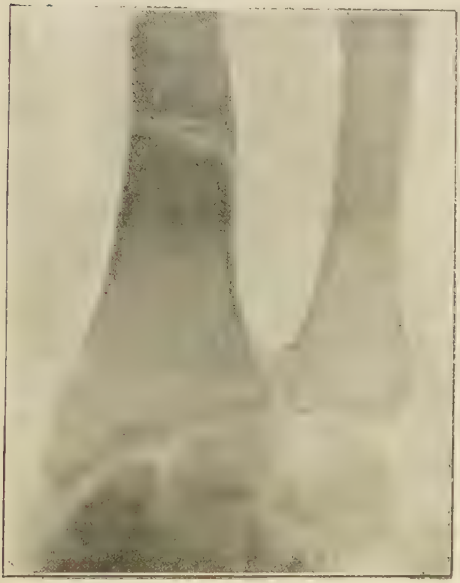

FIG. 226.—FRACTURE OF SHAFT OF RADIUS. (ANTERO - POSTERIOR VIEW.)

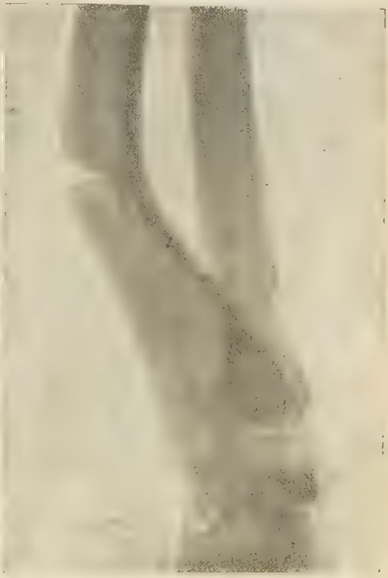

FIG. 227.—FRACTURE OF SHAFT OF RADIUS. (LATERAL VIEW.) From the same patient as Fig. 226, and showing excellently the necessity for taking radiograms from two points of view.

When the fracture is placed *below the insertion of the pronator teres*, the upper fragment is drawn forwards by the action of the biceps, and inwards by the pronator, assuming a position midway between pronation and supination; the lower fragment may be slightly approximated to the ulna by the direct action of the pronator quadratus; the hand is fully pronated looking downwards. Union to the ulna by callus thrown across the interosseous space is not unlikely to occur. **Treatment.**—The arm is placed midway between pronation and supination, and the hand fully adducted. The fragments are manipulated into position, and splints applied back and front. It is wise to place a good pad under the palmar splint over the site of fracture so as to repress the tendency to anterior displacement of the fragments; a Gordon's splint is useful in this direction.

4. The **Lower End of the Radius** is broken with extreme frequency, constituting what is known as **Colles's Fracture.** This injury occurs most commonly in women of advanced years, although it may happen at any age or to either sex. It is almost invariably due to falls upon the outstretched palm, when the hand is completely pronated and extended. The line of fracture is placed about 1 inch from the wrist, though rather under than over this. It is usually transverse from side to side, but is oblique in an antero-posterior direction, sloping from above downwards and forwards, so that the fracture is nearer the wrist-joint in front than it is behind (Fig. 231).

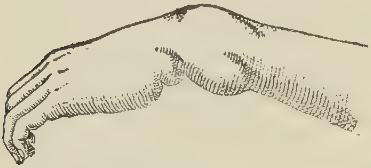

FIG. 228.—COLLES'S FRACTURE: LATERAL VIEW.

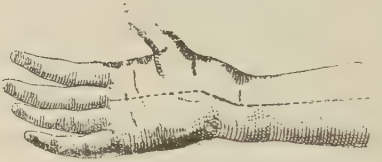

FIG. 229.—COLLES'S FRACTURE: PALMAR VIEW.

The *displacement* is somewhat complicated. (*a*) The lower fragment is carried backwards and a little upwards, owing to the direction of the violence, viz., a fall on the outstretched hand, the radius being compressed between the ground and the weight of the body, and yielding at what is evidently a weak spot; this deformity is maintained by the radial extensor muscles of the wrist, and often by impaction of the fragments. (*b*) From the fact that the main violence is received on the thenar eminence, the outer side of the lower fragment is displaced more than the inner, which remains fixed to the ulna by the strong inferior radio-ulnar ligaments. This position is in part kept up by the extensors of the thumb and the supinator longus, but mainly by impaction of the fragments. The hand and carpus always follow the lower fragment, and hence the former is abducted, causing the styloid process of the ulna to become prominent (Fig. 230), and lower than that of the radius, whereas it is normally placed on a slightly higher level. In bad cases the styloid process of the ulna is actually torn off, or the internal lateral ligament ruptured, allowing displacement outwards of the whole hand. (*c*) The lower fragment is also rotated around a transverse axis, so that the lower articular surface looks backwards as well as downwards, a displacement due to the fact that in falling the force is directed, through the carpus, more to the posterior than to the anterior aspect of the bone. (*d*) The upper fragment is pronated and approximated to the ulna by the pronator quadratus muscle

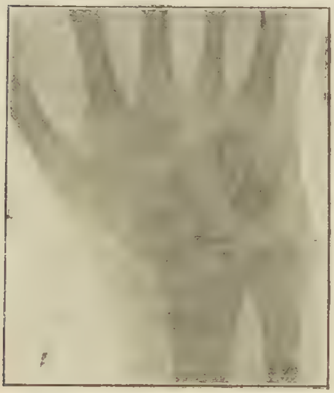

Fig. 230.—Colles's Fracture: a Simple Case, without Much Lateral Displacement of Hand.

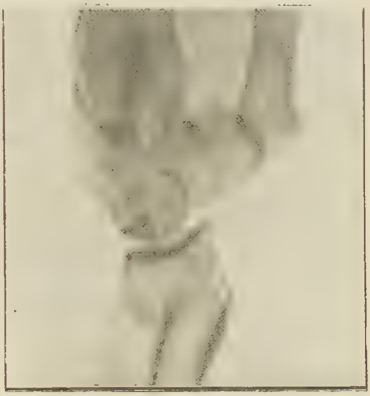

Fig. 231.—Lateral View of Colles's Fracture, showing Displacement Backwards and Upwards of the Lower Fragment.

The *deformity* produced by the fracture is therefore very characteristic. The hand is in a position of radial abduction, and usually pronated, with the fingers somewhat flexed (dinner-fork deformity). Three abnormal osseous projections are present: (i.) The styloid process or head of the ulna is very marked, owing to the radial abduction of the hand (Fig. 229); (ii.) on the back of the wrist is a prominence which terminates abruptly above, caused by the projection of the lower fragment (Fig. 228); and (iii.) corresponding to this dorsal projection there is a well-marked depression on the palmar surface, and above it a less sharply defined swelling, which gradually shelves into the fore-arm, due to the upper fragment. Pronation and supination are lost, and, as a rule, there is neither crepitus nor preternatural mobility, owing to impaction of the fragments. An important diagnostic point is the relative position of the two styloid processes; normally, that of the radius is below that of the ulna, but in cases of fracture it is on a level with or above it.

As already stated, the fracture is commonly impacted, the upper fragment being firmly driven into the cancellous tissue of the lower end; excess of violence may, however, disimpact, but often at the expense of comminution of the lower fragment. Union is effected without difficulty, but the patient should always be warned at an early date to expect some deformity about the wrist, as well as considerable impairment in the subsequent mobility of the fingers and hand, owing partly to adhesions in the joint, partly to blood trickling down the tendon sheaths and fixing the tendons.

Treatment.—It is most important completely to reduce the deformity, and to this end extension and manipulation are both needed. The patient, if not under an anæsthetic, should be seated on a chair, and the surgeon, standing in front, should grasp the hand firmly, using the right hand for fractures on the right side, and the left for those on that side. Counter-extension is made from the flexed elbow, and the hand is then forcibly extended and adducted; disimpaction is thus brought about, and a little manipulation enables the fragments to be moulded into position. In old people, however, where impaction is present, it may be wiser to leave things alone and not to attempt disimpaction or correction of the deformity.

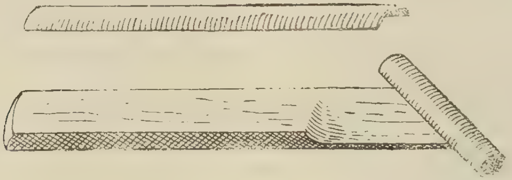

FIG. 232.—CARR'S SPLINT FOR COLLES'S FRACTURE OF LEFT HAND.

When once the deformity has been corrected, there is but little tendency for it to reappear, and therefore the use of elaborate retentive apparatus or splints is quite unnecessary in the majority of cases: (1) Perhaps the simplest and most efficacious is a piece of Gooch splint, shaped so as to cover the radius front and back as far as the middle line of the arm, and extending nearly from the elbow to the front and back of the knuckles of the index and middle fingers: its lower end is hollowed out in a horseshoe manner, so as not to reach beyond the end of the metacarpal bone of the thumb. This is well padded and firmly bandaged on; it grasps the radius and steadies the hand in a position of adduction, without in any way interfering with the movements of the fingers. (2) *Carr's splint* (Fig. 232) may be used in some of the more severe cases, especially when the ulnar styloid process has been fractured. It consists of two portions fitting the front and back of the radial side of the forearm, whilst to the palmar one is attached an oblique rod to be grasped by the fingers, and thus the hand and wrist are maintained in a position of adduction, whilst the fingers can be freely moved. (3) *Gordon's splint* is another excellent contrivance occasionally useful, which consists of two pieces. The palmar portion has a curved projection on its radial side, to correspond to the site of the fracture and to the concavity of the lower end of the radius; on the ulnar side it is prolonged, so as to fit the ulnar border of the hand. The dorsal splint is slightly curved at the lower end, so as to apply itself comfortably to the wrist when in a position of flexion.

Union is usually firm enough in a week to permit the removal of the splints, the arm being kept in a leather or poroplastic support for some time longer. Massage and passive movements should be employed, and the fingers left free and exercised after the first two or three days.

A fracture of the lower end of the radius, known as *Smith's fracture*, is occasionally met with, in which the displacement of the fragments is exactly the reverse to that seen in Colles's fracture, viz., the lower end of the radial shaft projects posteriorly, whilst the lower fragment is displaced anteriorly. **Treatment** is conducted as for a Colles's fracture.

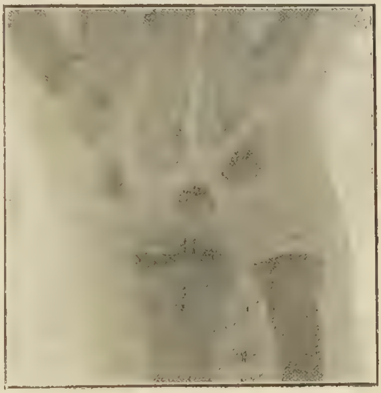

FIG. 233.—RADIOGRAM OF DISPLACEMENT OF LOWER EPIPHYSIS OF RADIUS AND OF THE HAND OUTWARDS.

5. **Separation of the Lower Epiphysis** of the radius occurs in young people under twenty, and when it is displaced backwards, simulates somewhat closely a Colles's fracture. The lower end of the diaphysis projects anteriorly to a much greater extent, and, indeed, may protrude through the skin of the wrist. The lower end of the ulna may be involved in the accident, either the epiphysis being separated, or the shaft broken a little above. This condition may be mistaken for a backward dislocation of the wrist, but a diagnosis can be readily made by observing the relative position of the styloid processes to the carpal bones. Lateral displacement occurs in some cases (Fig. 233). **Treatment** is practically the same as for Colles's fracture.

Should arrest of growth result from this accident, the hand retains its connection with the stunted radius, but the ulna continues to grow downwards, and its lower end is found on the inner and posterior aspect of the carpus, which is pushed *en bloc* towards the radial side, but without any marked abduction (Madelung's deformity).

Fracture of both Bones of the Fore-arm may result from direct violence or falls on the palm. Any part of the bones may yield, but the middle and lower thirds are most frequently affected (Fig. 234). When due to direct violence, both bones may be broken at the same level; but if due to a fall on a palm, the ulna usually gives way at a higher level than the radius. The line of fracture may be transverse or oblique, and the displacement varies both with this and with the force employed. The upper fragments are usually drawn together and pronated, whilst the lower end of the radius is drawn up by the supinator longus. In young people a not uncommon result of falls in the football field or at the skating-rink is a complete fracture of the lower third of the radius, and a greenstick fracture of the ulna. The upper fragment of the radius is displaced forwards in front of the pronator quadratus, which prevents its replacement even by traction under an anæsthetic. The diagnosis of these fractures is very simple, since there is, as a rule, obvious deformity. **Treatment** consists in reduction by extension conjoined with manipulation, and the application of splints which will prevent cross-union of the bones. If the fracture is above the insertion of the pronator teres, the arm must be put up in full supination, as suggested for a similar fracture of the radius alone (p. 519), whilst below that spot the usual position midway between pronation and supination may be allowed. Union is generally complete in five or six weeks. If the fragments are not readily manipulated into position, as indicated by radiography, operation should be undertaken without delay, as the middle or lower end of these bones is a rather favourite site of election for non-union (Fig. 197).

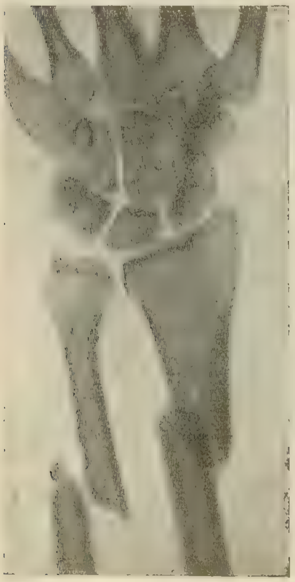

FIG. 234. — FRACTURE OF BOTH BONES OF THE FORE-ARM.

Fractures of the Carpus.—These may result from direct violence in the nature of a severe crush, and then several of the bones may be involved, and the lesion may be compound. The ordinary treatment of such a condition must be followed, and the parts kept at rest on a palmar splint.

Radiography has demonstrated that many 'sprains of the wrist' from indirect violence are in reality associated with fracture of a carpal bone, and of these a transverse fracture through the waist of the scaphoid (Fig. 235) is perhaps the most common. As a rule, rest and subsequent massage are alone required; but occasionally movement is impaired by a displaced fragment, or painful weakness follows from non-union, and then removal of the fragment or of the bone is necessary.

Fractures of the Metacarpal Bones and Phalanges are not uncommon, particularly in the third and fourth fingers, being due to direct violence, and hence usually transverse. There is generally but little displacement, though occasionally the fragments may overlap, whilst a certain amount of localized swelling and tenderness is always noted. The treatment usually required is immobilization for a short time, and for the phalanges a small zinc splint moulded along the front of the finger acts admirably. Should the fragments overlap, operation may be necessary.

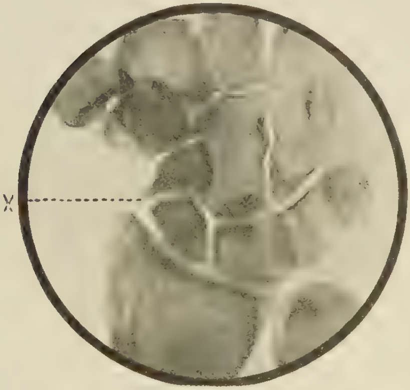

FIG. 235.—FRACTURE OF THE WAIST OF THE SCAPHOID (X) IN A PATIENT SUPPOSED MERELY TO HAVE SPRAINED HIS WRIST.

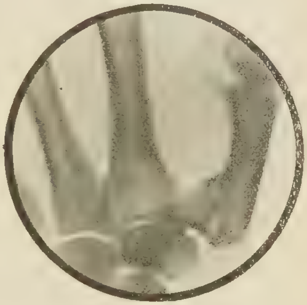

FIG. 236.—RADIOGRAM OF A 'STAVE OF THE THUMB' FRACTURE.

Bennett, of Dublin, has described an interesting fracture of the first metacarpal (*stave of the thumb*), which is due to indirect violence, and not very rare. The line of fracture is oblique (Fig. 236), separating the anterior portion of the base, which remains *in situ*, from the rest of the shaft, which is drawn upwards and backwards by the long extensor tendons, so as to lie behind the trapezium. Should the displacement be overlooked, the bone unites in this position, and the deformity, which persists, determines weakness and disability of the thumb. **Treatment.**—The fracture is reduced by traction. A poroplastic splint is moulded to the anterior (palmar) aspect of the thumb, reaching above the wrist; it is first fixed to the distal end by strapping, and then bandaged above, so that extension is continuously applied.

Fractures of the Pelvis.

Fractures of the pelvic bones are almost always the result of direct injury, such as falls, blows, gunshot wounds, or crushes in railway, carriage or cart accidents. For convenience they may be described under the following headings:

1. **Fractures of the False Pelvis.**—A portion of the crista ilii may be broken off, or the anterior superior spine separated, or merely a fissure in the bone produced. The displacement is rarely great, although a portion of the crest may be drawn down by the glutei muscles, or the anterior superior spine displaced by the sartorius. Considerable pain is always present, especially on any vigorous respiratory movements, but crepitus is rarely to be detected. Union occurs readily if the patient is kept quiet in bed with the shoulders raised, and the legs supported to relax the muscles. A flannel bandage round the pelvis gives comfort and support.

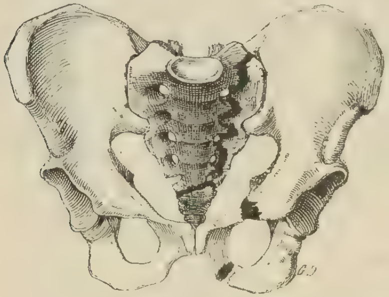

FIG. 237.—UNILATERAL FRACTURE OF THE PELVIS. (MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.)

The fracture runs through the sacrum on the left side, and through the horizontal and descending rami of the pubes.

2. **Fracture of the True Pelvis** is a much more serious accident. The line of fracture in front usually runs into the obturator foramen, and involves both the horizontal and descending rami of the pubes or the ascending ramus of the ischium (Fig. 237). This is frequently conjoined behind with a fracture in the neighbourhood of the sacro-iliac synchondrosis either on the same or opposite side, but more frequently the latter; whilst a double fracture, front and back, may also occur at these, the weakest, points. The cause of the posterior fracture is that, when the pelvic ring has yielded anteriorly from the violence, the continued strain, whether directed from the front or from the sides, must necessarily fall on the part where the ilium is most closely connected with the sacrum, and the bones then give way rather than the unyielding and powerful sacro-iliac ligaments. Probably the fracture involves the lateral mass of the sacrum rather more frequently than the ilium. The **Symptoms** are those of severe shock and pain in and around the pelvis, especially on movements of the legs or on coughing. There may be local ecchymosis and tenderness over the pubic ramus, as also deeply in the iliac fossa, and the patient either cannot stand, or feels as if he were falling to pieces on attempting to do so. Usually there is but little deformity, although occasionally displacement backwards of the innominate bone is

visible, and depression of the pubic symphysis or of the ischial or pubic rami may be palpable. Crepitus may be elicited on grasping the iliac bones, and moving them one on the other; but such a method of investigation must be very sparingly indulged in.

The chief dangers from a fractured pelvis arise from the presence of co-existent *visceral lesions*, especially to the urethra, bladder, or rectum. The membranous portion of the urethra is torn by the displacement of the pubic symphysis, and this is indicated by escape of blood from the meatus. Every effort must be made to prevent extravasation of urine, and *the patient warned against passing water, however urgent the desire.* Rupture of the bladder results in pelvic or intra-peritoneal extravasation, according to the site of the lesion. The rectum may be punctured by the displaced pubic rami, and on examination the ends of the bones may be felt in the rectum. The vagina and the pelvic vessels and nerves are less frequently injured.

Treatment.—The patient should be moved with the greatest care, both on account of the shock, and also for fear of producing or increasing visceral complications. He is put to bed on a firm divided mattress with fracture-boards beneath it, and kept quiet until the shock has in measure passed off. A more complete examination is then made, if need be under an anæsthetic, and complications dealt with. It is rarely desirable to attempt replacement of the fragments, which gradually return to a more or less normal position. The pubes, however, may be pushed forwards by a finger in the rectum or vagina. A many-tailed bandage or broad binder is advisable to steady the parts, and the patient's knees must be tied together; he must of course be rolled over on the sound side in order to wash the back.

The visceral complications demand suitable treatment, and especially the urethra, which must be examined in all cases and the water drawn off by a sterilized catheter. If the urethra is torn, it may be possible to pass a catheter and tie it in; but failing this, a perineal incision must be made in order to prevent urinary infiltration. If the pubic rami are also felt projecting into the rectum, it may be advisable to prolong the perineal incision backwards so as to lay open that viscus freely, thereby allowing free exit to fæces and discharge, and permitting of more satisfactory cleansing.

Apart from complications union may be expected in about six weeks, but the patient should be kept in bed for at least eight, and even then only allowed to get about on crutches, wearing a padded belt. Late complications in the form of abscesses connected with necrosis of the pubic rami or pelvic extravasation may, of course, arise, and prove fatal or delay convalescence.

3. **Fracture of the Acetabulum** is of two types: (1) The posterior lip is broken off by the head of the femur, which is dislocated backwards by the same accident. Reduction is effected easily and with crepitus, but the displacement usually recurs, and to prevent it prolonged and effective extension is required. (2) A heavy fall on the trochanter may cause (*a*) a simple fissure extending into or across the

cavity, or (*b*) a starred fracture, possibly resolving the cavity into its three constituent elements, or (*c*) it may even drive the head of the bone into the pelvis (*central dislocation of the femur*). A mere fissure of the acetabulum produces but few symptoms beyond a little pain and impairment of movement; but if the head of the bone is driven into the pelvic cavity, the symptoms are much more serious, on account of the associated injuries to the viscera and the greater amount of violence employed. The case will resemble one of fracture of the neck of the femur, but there is usually only very slight mobility, and the head may be felt within the pelvis on rectal examination. An attempt should be made to free it by horizontal traction outwards, and manipulation through the rectum; extension is then maintained, and passive movement commenced early.

4. **Fracture of the Tuber Ischii** has been known to occur from falls in the sitting position. The diagnosis is often obscure, as the displacement is slight.

5. **Fracture of the Sacrum** is always due to direct violence of considerable severity, such as kicks, blows, or gunshot wounds. It is not unfrequently comminuted, and, from the associated injury to the lower sacral nerves, may result in loss of power of the bladder and rectum. In a transverse fracture, the lower fragment is usually displaced forwards, and may cause pressure upon the rectum; irregularity in the shape of the bone may be detected from within (*per rectum*) or from without. **Treatment.**—The lower fragment should be replaced, if possible; but considerable difficulty may be experienced in keeping it in position. A well-fitting pelvic band, with rest in bed, is probably all that is necessary.

6. **Fracture of the Coccyx** occurs during parturition or results from falls or blows, although its mobility often protects it from injury. Great pain is felt on walking, or on any movement which increases the intra-abdominal pressure, such as straining, coughing, defæcation, etc., since the coccygeus muscle forms part of the pelvic diaphragm. A rectal examination reveals preternatural mobility of the lower fragment, angular deformity, and perhaps crepitus. The **Treatment** consists in keeping the patient at rest until union has occurred; it is impossible to apply any apparatus, and hence the bone may unite at an angle, causing pain, discomfort, and difficulty in parturition. *Excision of the bone* is then required. The patient lies semi-prone with the legs slightly flexed, or in the lithotomy position, and a longitudinal incision is made in the middle line. The apex and lateral margins of the bone are cleared, and the ligamentous tissues uniting it to the sacrum divided by the knife; the bone is now laid hold of by sequestrum forceps, and its remaining attachments severed, due precautions being taken not to encroach on the rectum. Two or three stitches are inserted, and also a drainage-tube for a few hours; the dressing is secured in position by a T-bandage. The bowels should be confined for some days after the operation.

Falls upon the coccyx, unaccompanied by fracture, sometimes give rise to a most severe and intractable type of neuralgia, known as

coccydynia, which may quite prevent the patient from following his avocations. It is probably due to adhesions forming between the posterior sacral nerves and the bruised periosteum. If all the usual sedatives fail in giving relief, the bone must be excised.

Fractures of the Upper End of the Femur.

1. **Fractures of the Neck of the Femur** may involve any portion of this region, but for clinical purposes are usually divided into those near the head and those affecting the base near the trochanter.

Fracture of the Cervix Femoris near the Head (the so-called *intra-capsular* variety, Fig. 238, A) is most frequently met with in persons of advanced age, and especially in females. This is explained by the atrophic changes which take place in the cervix femoris of elderly people. The spaces between the bony cancelli are enlarged and loaded with soft fat, whilst the ensheathing compact tissue is thinned, and the 'calcar femorale' of Merkel (*i.e.*, the process of thick cortical substance running from the lesser trochanter to the under part of the head) is atrophied. As a rule it requires but little violence to produce a fracture, the direction of which varies according to the force applied. The accident is often due to some slight stumble or fall, such as slipping off the kerb or tripping upstairs; the bone yields in consequence, and the patient falls to the ground. The line of fracture may be transverse or oblique, and is mainly intracapsular. Some of the fibres reflected from the under surface of the capsule to the head of the bone may remain untorn at first, but later on they may give way from inflammatory softening, injudicious manipulation, or attempts to use the limb. The fracture is not usually impacted; if, however, this condition should occur, the upper end of the neck is driven into the loose cancellous tissue of the head. The *displacement* is necessarily limited entirely to the lower fragment, which is drawn upwards by the glutei, recti, and hamstring muscles, and rotated outwards and somewhat backwards, so that the fractured surface looks almost directly forwards.

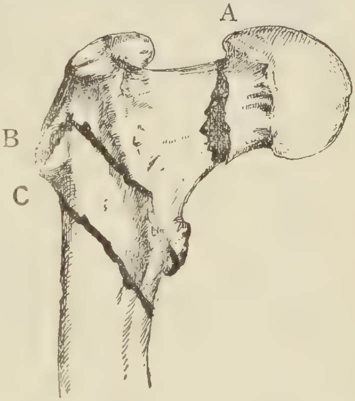

FIG. 238.—A, FRACTURE OF THE CERVIX FEMORIS NEAR THE HEAD. B, PERTROCHANTERIC FRACTURE. C, SUBTROCHANTERIC FRACTURE.

The course of the case depends to a large extent upon the general condition of the individual. If he is healthy and free from chronic pulmonary affection, so that he can be kept recumbent for six or eight weeks, bony union may certainly occur. This takes place mainly from the lower end, as the vascular supply of the head is only just sufficient to maintain its vitality. If, however, the patient is feeble and weakly, and especially if the subject of chronic bronchitis and emphysema, the prognosis is by no means good, since hypostatic pneumonia and extensive bedsores may carry him off during the short stay in bed which is always necessary in order to relieve the more urgent symptoms of pain. Bony union is never, under these circumstances, to be expected, and a loose fibrous union, or even a false joint, is the best that can be looked for. Not unfrequently the joint undergoes changes akin to those of osteoarthritis, and the patient henceforth suffers much pain and discomfort. Sometimes the neck is absorbed and the shaft slips up on the dorsum ilii, the weight of the body being carried by the outer limb of the Y-ligament of Bigelow and the obturator internus tendon. The prognosis is, of course, much improved by the presence of impaction, and the fear of breaking this down must ever be in the mind of the examining surgeon; whilst the integrity of bridges of periosteum and reflected fibres from the capsule also improves the outlook.

Radiographic examination has shown that a similar type of fracture occurs *in children and young people.* It is not unfrequently incomplete, and may be associated with bending of the neck. The patient often recovers mobility of the limb, and can walk about after resting in bed for a few days; but the deformity persists, and, in fact, increases from further yielding of the softened bone, so that in time coxa vara results. A similar deformity follows a partial or complete separation of the upper epiphysis. A mistaken diagnosis of tuberculous coxitis may be made, unless one clearly appreciates the rapid appearance of the symptoms after an injury, and the facts that the trochanter is raised, the limb shortened, and the movements limited only in particular directions or not at all. If there is complete separation, treatment is best carried out by fixation with plaster of Paris in an abducted position, and by prolonged freedom from the body-weight, so as to allow the callus to harden, as by the application of a Thomas's hip-splint.

Fracture of the Cervix Femoris near the Trochanter (the so-called *extracapsular fracture*) always involves the hip-joint, since the capsule extends to the shaft of the bone along the anterior intertrochanteric line, and leaves no portion of the neck uncovered in this situation. The line of fracture (Fig. 239) is placed in front, either along the attachment of the capsule or well within it, and is really only extracapsular behind; sometimes, however, the shaft itself is considerably encroached on.

Mechanism.—This fracture is usually the result of violence acting transversely upon the trochanter major, as from a heavy fall upon the hip. The posterior part of the neck, being weaker than the anterior, first gives way; the whole neck then yields, and the severed head and neck are impacted into the junction of the trochanter and shaft. The majority of these cases are thus primarily impacted, continuation of the violence producing disimpaction, coupled either with detachment of one or both trochanters, or with comminution of the great trochanter; at least three, and perhaps four, fragments are thus produced (Fig. 240). Disimpaction may also follow at a later date from the rarefaction associated with the early stages of repair or from injudicious manipulation; and thus the shortening which may at first be slight often increases at the end of a few days. The upper fragment remains in the acetabulum, whilst the lower is drawn up and everted.

Union of the fragments is much more certain in this variety than in the intracapsular, but it is often accompanied by a considerable development of callus, which may subsequently impair the movements of the limb, whilst secondary bending and late increase of the shortening may occur if the patient walks too soon.

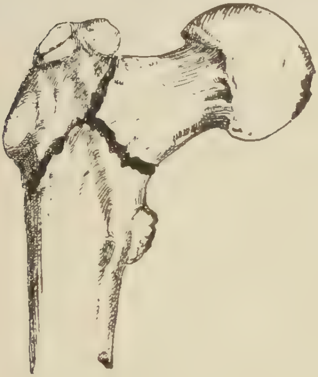

FIG. 239.—FRACTURE OF CERVIX FEMORIS NEAR THE BASE. (SEMI-DIAGRAMMATIC, FROM THE FRONT.)

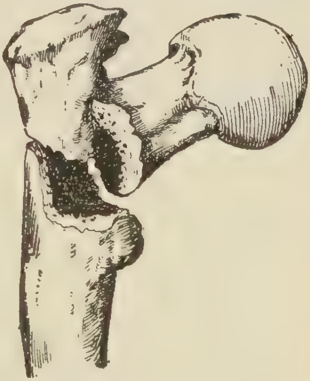

FIG. 240.—FRACTURE OF NECK OF FEMUR NEAR THE BASE, SEEN FROM BEHIND. (COLLEGE OF SURGEONS' MUSEUM.)

The head and neck are depressed, and the trochanter major drawn slightly upwards.

The **Signs and Symptoms** of these two fractures may well be considered together, the points of similarity and contrast being in this way more effectually emphasized.

(*a*) The signs of *local trauma*, viz., pain, bruising, and swelling, may be present in both; but whilst slight in the intracapsular variety, they are often very marked in the extracapsular.

(*b*) *Crepitus* is evident in the unimpacted forms of each; but it is unnecessary and, indeed, extremely unwise to elicit it by forcible manipulation, especially in the intracapsular variety.

(*c*) *Loss of power* is perhaps more marked in the extracapsular form than in the intracapsular. Cases of the latter in which the patient was able to walk into hospital some days after the accident are not unknown, and are probably due to impaction.

(*d*) *Eversion* is a most characteristic feature in both varieties, the limb lying absolutely helpless on its outer side. This displacement is accredited to the natural weight of the limb, to the greater fragility of the back of the cervix, causing it to be more comminuted than the anterior surface, and, lastly, to the greater power of the external rotator muscles. *Inversion* has been met with in a few rare cases, but is probably due to the violence in the particular instance being directed from behind forwards, and to impaction of the fragments.

(*e*) *Shortening* is slight in the early stage of intracapsular, and much greater in the extracapsular, fractures, even reaching to 2½ or 3 inches. It is indicated by displacement of the trochanter upwards, due allowance being made for the position of the limb as regards abduction or adduction.

(*f*) The *position of the great trochanter* is of the greatest importance. It is raised above its ordinary level, and displaced backwards owing to eversion of the limb; and it is approximated to the middle line of the body. The demonstration of this position is most important and, amongst others, the following tests are employed:

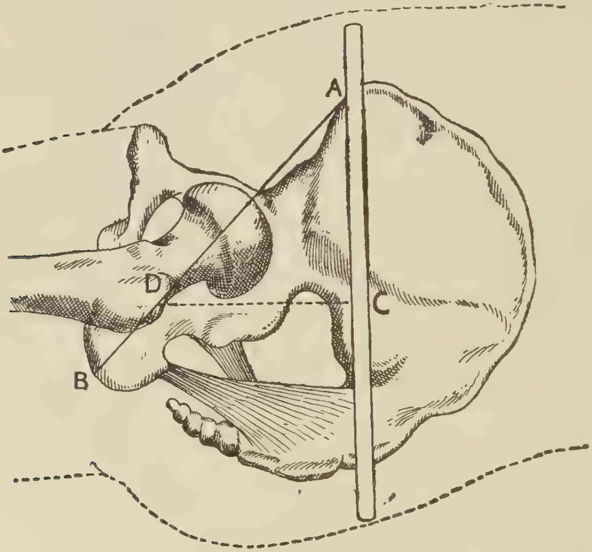

FIG. 241.—NÉLATON'S LINE AND BRYANT'S MEASUREMENT FOR ASCERTAINING POSITION OF GREAT TROCHANTER.

Nélaton's line (Fig. 241) is one drawn from the anterior superior spine to the most prominent point of the tuber ischii (AB). The centre of this (D) corresponds to the top of the great trochanter, if the limb is placed in the axis of the body; but if either abduction or adduction is present, the top is situated slightly above or below the line. Definite elevation of the bone above the line indicates shortening of the limb due to dislocation backwards, fracture of the neck, or absorption of the head and neck from disease.

Bryant's Test Line (Fig. 241).—In this the patient lies flat on a horizontal couch, and a vertical line (AC) is drawn from the anterior superior spine; a thin wooden rod held against the side answers this purpose admirably. The perpendicular distance of the top of the great trochanter from the line (CD) is compared with a similar measurement on the opposite side; definite shortening may thus be discovered. In the normal adult this measurement is usually about 2½ inches.

Morris's bitrochanteric test indicates the amount of inward displacement. It is conducted by measuring the distance between the outer surfaces of the trochanters and the middle line of the body by means of a rod graduated from the centre, along which two pointers work outwards. Shortening in this direction will also be observed in most dislocations of the hip-joint.

Moreover, in the extracapsular fracture a considerable amount of *thickening* of the trochanter is always produced, owing to the excessive development of callus. In the intracapsular variety it is rarely fissured or injured, and therefore no thickening occurs.

(*g*) Lastly, *relaxation of the fascia* between the crest of the ilium and the great trochanter (that is, of the upper part of the ilio-tibial band) is given as a characteristic feature of these fractures.

Diagnosis.—A *severe contusion* of the hip, which may be associated with marked eversion, is known from a fracture by the absence of shortening and crepitus; there is no displacement of the trochanter, which rotates in a normal manner. The shortening which sometimes follows, owing to subsequent atrophy of the neck, may, however, complicate matters. In a *dislocation* the head of the bone can be felt in an abnormal position, and hence no difficulty should be experienced in its recognition. In *chronic osteo-arthritis* of the hip a patient may fall and present for examination a limb with definite shortening and marked bony crepitus. It will be found, however, that there is no acute eversion, pain, or loss of power, whilst the existence of similar disease in other joints may assist the surgeon. Moreover, osteo-arthritis of the hip usually results in prominence of the trochanter, and not in flattening, as occurs after fracture; the fascia, too, above the trochanter is never relaxed in osteo-arthritis, always in fractures. It must not be forgotten that, after an intracapsular fracture, the patient may fall, not on the injured side, but on the sound thigh, and cases have been known where the surgeon's attention was directed to the wrong limb owing to the amount of bruising there manifested.

The **Treatment of Intracapsular Fractures** must depend in great measure, as already stated, upon the individual. If old, weakly, and with a tendency to chronic bronchitis, long confinement to bed would have a most deleterious, if not fatal, effect. In such cases the limb is put at rest for a few days between sandbags, and cooling lotions applied. Some suitable appliance, such as a Thomas's splint with mechanism for extension, or a plaster of Paris spica, should be fitted as early as possible, and the patient encouraged to get about on crutches.

In a healthy individual with good physique, a determined effort must be made to secure bony union, and this will involve the patient being kept in bed for six or eight weeks. Reduction is obtained by making manual extension on the limb, a roller-towel around the perineum being employed for counter-extension. This is maintained until the limbs correspond in length, and then the leg is inverted so that the foot is at right angles to the table, and the whole limb is slowly abducted under tension so as to bring the lower fragment into contact with the upper; only in this position can satisfactory apposition of the fractured surfaces be obtained. The patient is then placed in a suitable abduction frame (Robert Jones) —a double Thomas's splint with the frame for one limb abducted—and extension maintained, or in a plaster of Paris spica (Royal Whitman). At the end of six weeks the leg is gently adducted, and a Thomas's knee-splint with extension, or some similar contrivance, is fitted, and massage and passive movements of the limb are undertaken. It is a mistake to commence walking too early, and the patient should always for a time have a support, such as a walking caliper (R. Jones),* which carries the weight of the trunk from the pelvis to the ground. Walking without support should not be permitted for at least three months.

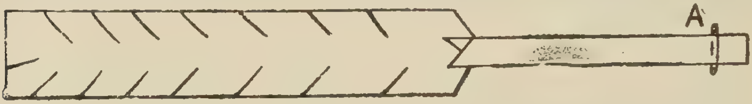

FIG. 242.—METHOD OF CUTTING AND FOLDING THE STRAPPING IN APPLYING EXTENSION.

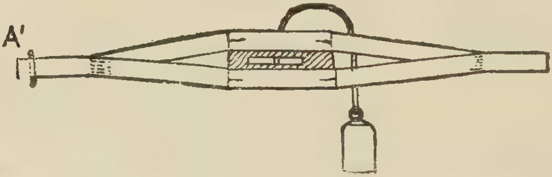

FIG. 243.—METHOD OF ARRANGING STRAPPING ON STIRRUP OR 'SPREADER.'

The end A¹ is attached by a safety-pin to A, the end of the upper piece of strapping in Fig. 242, and a similar attachment is made on the other side of the limb to the other piece of strapping.

Occasionally it may be justifiable to trust to weight-extension or to the use of a Liston's splint, but the results of such treatment are far inferior to those obtained by abduction. *Extension by weight and pulley* is required in so many different conditions that a description of its method of application is necessary. Two pieces of broad adhesive plaster are prepared as in Fig. 242; they should reach from well above the knee to the malleoli. The upper ends are notched obliquely to make them fit better to the limb, whilst the lower are folded on themselves so as to cover in the adhesive surface. A stirrup is then prepared as in Fig. 243; adhesive plaster is fixed to a wooden spreader, rather broader than the ankle, with a hole in its centre for the passage of a cord. The long strips are applied on either side of the limb, and secured to it by a woollen or boracic bandage, which should not extend much below the knee. The stirrup is then attached to the strips by safety-pins (A^1 to A); the cord is passed over a pulley fixed to the end of the bed, and to it is attached a suitable weight; the weight employed varies in different cases, but as a rule not more should be applied in fractures than

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* Robert Jones, *Brit. Med. Journ.*, December 7, 1912.

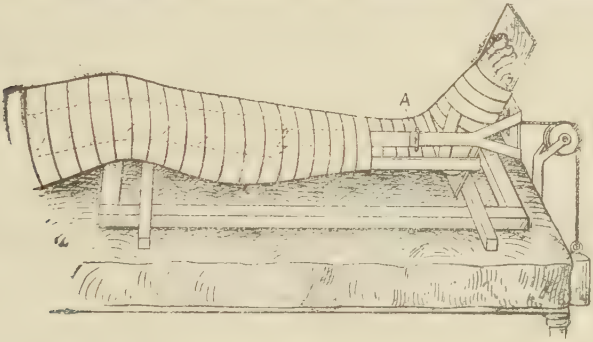

FIG. 244.—VOLKMANN'S SLIDING REST FOR FRACTURES OF THE FEMUR

A points to the junction of the upper and lower pieces of strapping, as in Figs. 242 and 243.

suffices to correct the shortening. The lower end of the bed is raised by placing the legs on blocks, so that the weight of the body may act as a counter-extending force.

In America *Buck's* method of *extension* is much employed and gives great satisfaction. The above-described extension is applied, but in addition a third strip of plaster, 1 yard long and 2 inches wide, is fixed to the back of the calf, brought down below the sole of the foot, and secured by a roller bandage. A Volkmann's sliding rest (Fig. 244) is then placed under the limb, and secured to it by the loose end of strapping and a bandage.

Liston's long splint (Fig. 245) is a useful and comfortable appliance, if rightly adjusted. It should reach from the axilla to about 6 inches below the ankle, and is fixed to the body either by bandages or by two broad sheets, which first firmly envelop the splint, and are then passed under and around the trunk and lower extremity respectively, and are finally secured by pins. Lateral movement or rotation is prevented by slipping the lower end of the splint into a slot between two 'angle-irons' screwed to a substantial wooden base, which rests on the bed.

In *impacted* intracapsular fractures no attempt should be made to separate the fragments. The patient is kept in bed and a long splint applied. A careful watch is maintained to ascertain if disimpaction has occurred, as then the ordinary treatment must be employed.

Treatment of Fracture near the Trochanter is usually conducted on similar lines to that of the intracapsular variety, but inasmuch as the patient is usually healthy a determined effort to secure satisfactory union must be made.

In the *unimpacted* form extension is the all-important element. It is usually conducted by weight and pulley; the weights must be heavy, and sometimes as much as 14 pounds are required; the strapping must reach well above the knee, or the ligaments of this articulation may suffer. Rotation may be prevented by fixing a broad piece of wood carefully padded transversely behind the knee by means of a plaster of Paris bandage. The addition of a long splint will keep the body at rest, but inasmuch as it might interfere with the extension, it may be as well to apply it to the sound side. Treatment in the abduction frame will also give good results. At the end of eight weeks the patient may be allowed to get about with a Thomas's splint and crutches, or a plaster spica.

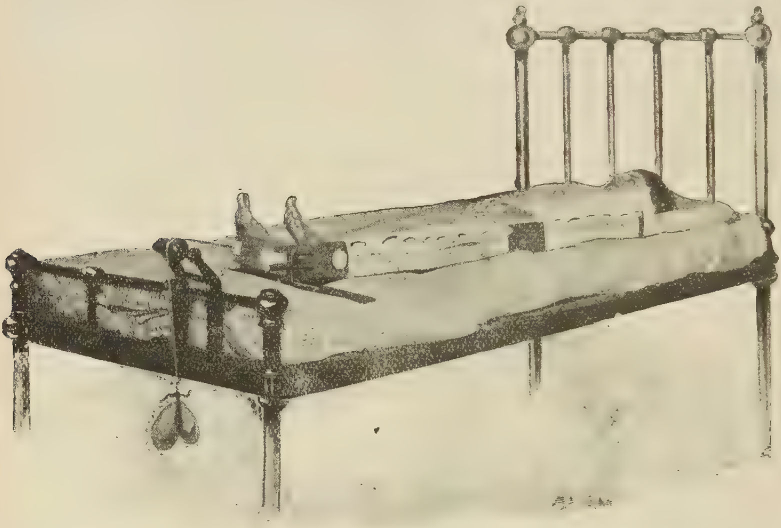

FIG. 245.—METHOD OF APPLICATION OF LISTON'S LONG SPLINT WITH WEIGHT EXTENSION.

The splint reaches from the axilla below the side of the foot, and is secured in place by sheets.

Impacted fractures should rarely be broken up, except in young and active people. In older patients the limb is kept at rest for six or eight weeks on a long splint without extension.

Union occurs readily and by means of bone; but there is often a good deal of deformity and subsequent disability from the development of bony outgrowths.

2. **Fracture of the Great Trochanter** is rare, and always due to direct violence; in the young it occurs as an epiphyseal lesion. The trochanter, or a portion of it, is separated from the rest of the bone without any loss of the continuity of the shaft. Independent movement of the fragment with crepitus is usually obtainable; and if the displacement is at all marked, an operation to fix it should be undertaken.

3. **Fracture through the Great Trochanter** (the *pertrochanteric* fracture of Kocher) closely resembles the extracapsular fracture, the lesion running from the inner and under part of the neck obliquely upwards and forwards through the base of the trochanter (Fig. 238, B). The lower fragment is displaced upwards and everted, and its upper edge can often be felt distinct from the top of the great trochanter, which does not move on rotation of the limb; there is also much thickening about the trochanter and pain on pressure over it. This injury needs to be carefully distinguished from the *subtrochanteric* fracture, which encroaches on the upper end of the shaft. In this both trochanters are included in the upper fragment (Fig. 238, C), which is flexed by the ilio-psoas and abducted, whilst the lower fragment is drawn up on its outer aspect and behind it with considerable shortening and complete eversion. Both types of fracture require prolonged extension in the abduction frame or by means of Hodgen's apparatus.

Hodgen's splint (Fig. 246) consists of a rigid iron frame in the form of the letter **U**, the outer and longer limb reaching from the anterior superior spine to 3 inches below the instep, and the inner from the adductor longus tendon to the same spot, where the two limbs unite in a crossbar 3 inches in width. The sides taper with the limb, and should be ¾ inch further apart than the diameter of the limb at any point. At the upper end the bars are united by an arch of the same material, which should correspond to Poupart's ligament; one or two similar arches are placed at equal points lower down. The splint is slightly bent at the knee.

Before applying the splint, an ordinary extension apparatus is attached to the limb. Strips of house-flannel, about 7 inches wide, are then cut and arranged beneath the limb at right angles to its direction, each one overlapping the next; the length of the strips should be rather more than the circumference of the limb at the spot to which each is to be applied. The splint is then placed in position; the strips of flannel are raised in succession, and, being lapped over the bar, are pinned or stitched there, so that the limb lies in a flannel trough, from which only the upper surface projects. The cord of the extension appliance is then securely tied to the lower end of the splint. Two hooks are soldered to each side of the frame, and to them are attached cords, which are brought together over the limb; another stout cord is tied to these, and passes over a pulley attached to a vertical post at the end of the bed; it is weighted to a sufficient extent. The limb when the weight is applied should lie free of the bed, even to its extreme upper limit. It is advisable to encircle the thigh in Gooch splinting, a narrow piece in front between the bars and a broader piece behind. These are well padded and secured by bandages which extend over the whole length of the apparatus; finally, starch is rubbed in so as to fix it more firmly. When correctly applied, the splint itself is pulled on by the extending force (the weight), and this is transmitted to the limb through the stirrup end, which should be taut ' like a harp-string '; laxity of this end indicates slipping of the splint, and necessitates its readjustment.

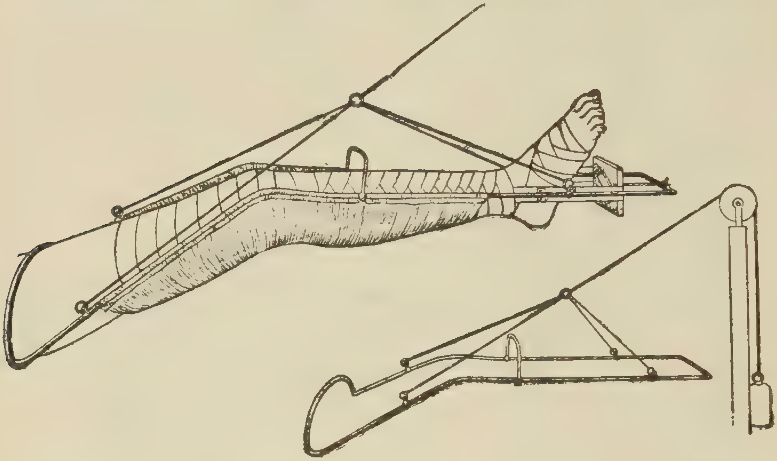

FIG. 246.—HODGEN'S SPLINT AND ITS METHOD OF APPLICATION.

Fractures of the Shaft of the Femur are extremely common accidents, in spite of the apparent strength of the bone. Any part may be involved, particularly the centre, whilst they occur at the lower end more frequently than at the upper. In the latter situation they are usually due to indirect violence, whilst at the lower end they generally result from direct injury; either form of violence may lead to a fracture about the middle of the bone, and radiography has shown us that spiral fractures are by no means uncommon. Exact diagnosis is sometimes difficult, owing to the amount of swelling from hæmorrhage, and to the muscularity of the part.

In almost every case *displacement* occurs, the direction and amount of which depend not only on the line of fracture, but also on the situation. In the *upper third* (Fig. 247), the small upper fragment is usually tilted forwards by the ilio-psoas, and abducted and everted by the gluteus minimus and external rotators; whilst the lower fragment is drawn upwards and to the inner side of the upper by the hamstring and adductor muscles, marked eversion also resulting, partly from the weight of the foot, and partly from the action of the adductors; but such a complicated displacement is not always present.

In the *middle third*, if due to indirect violence, the line of fracture usually slants from above downwards and backwards, causing a simple overriding of the fragments or an angular deformity. The lower fragment is drawn upwards and inwards, either in front of or behind the upper fragment, and is usually everted. The upper fragment is sometimes tilted forwards. If due to direct violence, the fracture is more or less transverse, often comminuted, and any form of displacement may then occur.

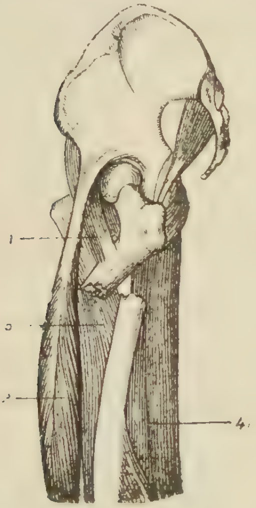

FIG. 247.—FRACTURE OF UPPER THIRD OF FEMUR, SHOWING DISPLACEMENT OF BONE. (AFTER GRAY'S 'ANATOMY.')

1, Ilio-psoas tendon; 2, rectus; 3, adductors; 4, biceps.

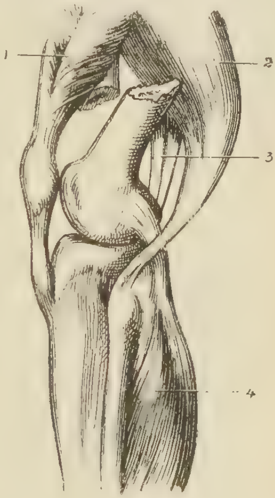

FIG. 248.—FRACTURE OF LOWER THIRD OF FEMUR, SHOWING DISPLACEMENT OF LOWER FRAGMENT BACKWARDS. (AFTER GRAY'S 'ANATOMY.')

1, Rectus; 2, biceps; 3, semi-membranosus and semi-tendinosus; 4, gastrocnemius.

In the *lower third* the fractures which arise from direct force are transverse; the lower fragment may then be tilted backwards by the gastrocnemii muscles (Fig. 248), and compress or rupture the popliteal vessels, perhaps causing gangrene. Oblique or spiral fractures from indirect violence, sloping from above downwards and forwards, are also met with; the upper fragment is driven into the substance of the quadriceps muscle and may become fixed in it, projecting immediately beneath the skin, whilst the lower fragment is drawn up behind. If such a case is left unreduced, non-union is likely to ensue; the knee-joint is generally penetrated by the lower end of the upper fragment.

Treatment.—In the *upper third*, where the upper fragment is often too short to be controlled by any splint, reduction of the deformity is accomplished by flexing the thigh, and making extension from the knee, the lower fragment being thus brought into the same axis as the upper. Manipulation will usually correct any lateral displacement. The limb must be confined in this position by some form of inclined plane, such as a Macintyre's splint, with a long thigh-piece, and with small straight wooden splints or a piece of Gooch's splinting fixed, if necessary, to the front and outer sides of the limb, over the seat of fracture. The splint is slung at the knee, the foot-piece being fixed to blocks of wood, a little lower than the level of the knee. If these precautions are not taken, an ununited fracture with the upper fragment in front of the lower, is likely to occur. Hodgen's apparatus also answers admirably in these cases, and where there is much abduction of the upper fragment the abduction

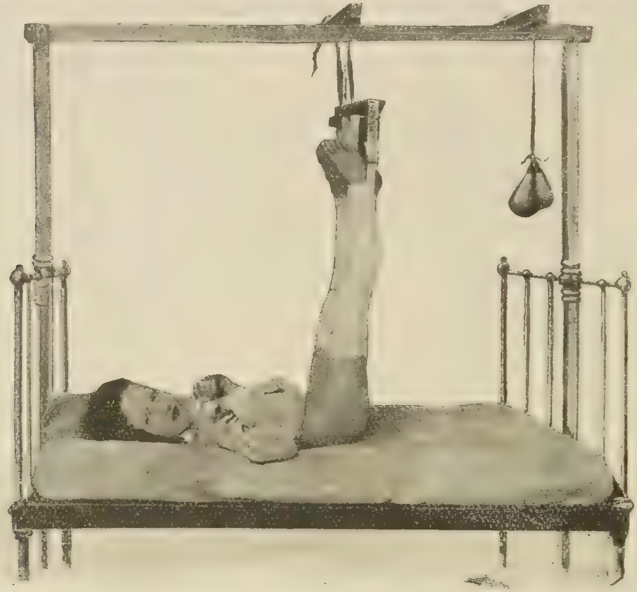

Fig. 249.—Bryant's Method of Extension for Treatment of Fracture of the Femur in Small Children.

The right leg is fractured and has the weight attached to it; the left leg is merely tied up to keep it vertical and out of the way.

frame (p. 534) may advisably be employed; in healthy patients, however, treatment by operation is often desirable.

In the *middle third* of the thigh, where the upper fragment can be controlled by splints, shortening is prevented by weight extension or by the use of a Thomas's knee-splint, the thigh being surrounded by pieces of Gooch's splinting, which grasp the muscles and keep the parts at rest. A half-box splint (*i.e.*, a long splint with a back-piece) may be successfully employed in many of these cases, the limb being firmly bandaged to the appliance. Where the fracture is oblique or spiral, and especially if there is any tendency to overlap, Hodgen's apparatus may be utilized, or operation undertaken.

In the *lower third*, when the lower fragment is tilted backwards, a Macintyre's splint, with a long thigh-piece and the knee well flexed, may sometimes be employed, together with a short anterior thigh-piece of Gooch's splinting; but in the oblique type, if the upper fragment has penetrated the quadriceps, operation alone holds out any prospect of bringing the parts into apposition, the muscular fibres being divided to allow the projecting end of the bone to be replaced, and fixed by screws or wire. In other cases the ordinary long splint or Hodgen's will be required.

In children, Bryant's plan of treatment (Fig. 249) is excellent; it consists in slinging the limb from a crossbar at right angles to the body, with or without a back-splint, reaching from the heel to the nates, and short lateral splints, thus obtaining extension by utilizing the weight of the body, whilst the bandages, etc., are kept from being soiled. If a long splint is used for children, a double one (*e.g.*, Hamilton's splint) with a crossbar below is the best. For the obstetric fracture which occurs in babies, the best treatment is to apply a small Thomas's knee-splint with extension. The ring which encircles the groin is well padded and covered with impervious oilskin, and the extension is carefully maintained.

A fractured femur usually unites well in from six to eight weeks, but the patient must not bear his weight on it for another month or two. Some form of retentive mechanism is employed, permitting walking, and yet maintaining slight extension—*e.g.*, a Thomas's knee-splint with a foot-piece. There is certain to be some amount of stiffness of the knee-joint, following effusion, after all fractures of the femur; but it generally passes away in time, and that without active surgical intervention.

Fractures of the Lower End of the Femur.

1. **T- or Y-shaped Fracture of the Condyles.**—In this a transverse fracture is complicated by a fissure, which runs into the joint, separating the two condyles; or a Y-shaped fissure may start from the intercondyloid notch. The condition is very painful; the joint is distended with blood; the bone may feel broader than usual, and crepitus may be detected. **Treatment** is best effected by operation,

in order to empty the joint of blood, bring the fragments into apposition, and fix them by screws or pegs.

2. **Separation of either Condyle** usually results from direct violence, but occasionally has followed such indirect injury as catching the toe against the kerbstone. There is no shortening, but the leg may be deflected towards the side injured, and the joint cavity be full of blood. The fragment, which is tilted backwards by the gastrocnemius, may move separately from the shaft, and give rise to crepitus. **Treatment.**—Reposition is effected by flexion of the limb, which is best put up in this position; but in healthy adults treatment by operation is desirable (Fig. 250).

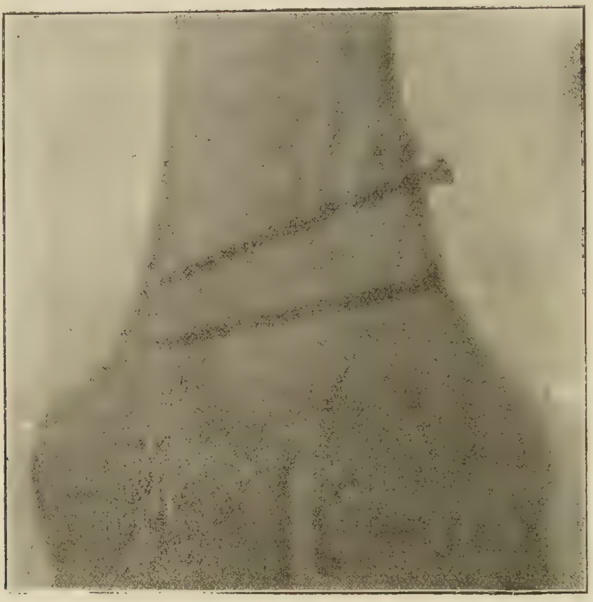

Fig. 250.—Radiogram of Fracture of External Condyle of the Femur, with Fixation of Fragments by Screws.

This fracture occurred in a healthy man, and was caused by catching his toe against the kerbstone whilst walking. The fragment was completely detached and drawn back into the popliteal space by the outer head of the gastrocnemius. It was treated by operation, with a good result.

Occasionally a small portion of the condyle may be detached and lie loose in the knee-joint; when the immediate symptoms due to the injury have subsided, the signs of a foreign body in the joint may become evident, and operation will be required for its removal.

3. **Separation of the Lower Epiphysis of the Femur** (Fig. 251) is not a very rare accident, and is frequently due to a child sitting behind a cab and getting a leg entangled between the

spokes of the revolving wheel. The limb is thus forcibly hyperextended at the knee, and the epiphysis yields, and is carried forwards. The lower end of the diaphysis projects behind, and may compress the popliteal vessels; gangrene has been known to result. As in the humerus, the line of separation does not always correspond to the epiphyseal line, but sometimes encroaches on the shaft. Suppuration occurs in a fair proportion of the cases. **Treatment.**—Reduction is effected by an assistant making traction on the tibia in the line of the limb so as to stretch the quadriceps; then the thigh is gradually flexed by the surgeon, standing above and with both hands clasped beneath it. The epiphysis is by this means restored to its normal position, and the limb is kept flexed by a bandage at about an angle of 60°, and laid on its outer side with an icebag applied. Passive movement is commenced carefully in a fortnight.

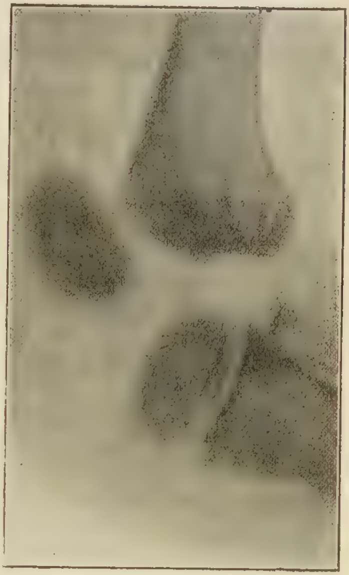

FIG. 251.—RADIOGRAM OF SEPARATION OF LOWER EPIPHYSIS OF FEMUR, WITH DISPLACEMENT FORWARDS.

The patella was mainly cartilaginous, and is not visible.

Fractures of the Patella.

The patella is broken either by muscular force or by direct violence, and the conditions produced are so different that a separate description is necessary.

1. **Fractures by direct violence** may traverse the bone in any direction, but are most often vertical or star-shaped, and frequently comminuted. They are usually mere fissures without displacement, owing to the aponeurosis or capsule of the bone remaining intact. There is a good deal of subcutaneous bruising, and perhaps some effusion into the joint, whilst on careful palpation the fissure may be felt, and crepitus occasionally detected. **Treatment** consists in keeping the limb at rest on a back-splint, and perhaps applying evaporating lotions. Massage and passive movements are commenced early where there has been much hæmorrhage into the joint. Operative measures are rarely required.

2. **Fractures due to muscular force** are always transverse, usually complete, and since they involve the fibrous aponeurosis, considerable displacement occurs.

Mechanism.—When the knee is semi-flexed, the patella is poised upon the front of the condyles of the femur, resting upon the middle of its articular surface: in this position any sudden and violent contraction of the quadriceps, as in attempting to recover one's equilibrium after having slipped, takes the bone at a disadvantage, and may succeed in snapping it. Possibly in some people there is a predisposing weakness, as cases are not rare in which the other patella is broken at a later date. The fragments may be almost equal in size (Fig. 252), but the lower is often the smaller; either of them may be again divided vertically, or comminuted.

The **Signs** of this fracture consist of loss of power in the limb, pain, distension of the joint with blood, and separation of the fragments, which can be readily felt and sometimes seen (Fig. 253). This displacement is due to unopposed muscular action, and is always associated with rupture of the lateral expansions of the vasti muscles. Union by bone is rarely obtained apart from operation, owing to the separation of the fragments, and the carrying in of loose tags of the fibrous aponeurosis or capsule, which yields at a different level to the bone. Fibrous union is the usual result, and when this is short and strong, it is quite satisfactory; but more commonly the bond of union yields when the limb is used, so that the two fragments are once again separated, merely a bridge of fibrous tissue intervening, the joint being left in a weak state, and the power of active extension of the leg lost.

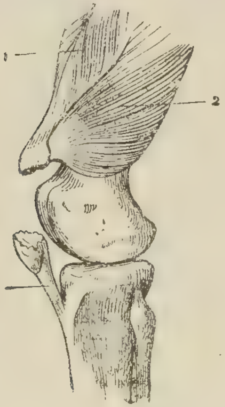

Fig. 252.—Fracture of Patella, with Separation of Fragments (After Gray's 'Anatomy.')

1, Rectus; 2, vastus externus; 3, ligamentum patellæ.

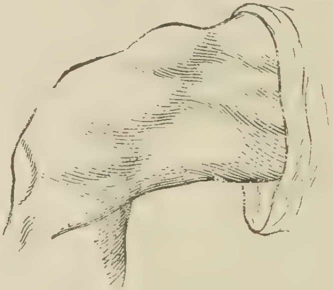

Fig. 253. — Appearance of Knee after Fracture of Patella.

The **Treatment** of these cases may be grouped under three headings, viz., by retentive apparatus, by subcutaneous operation, or by the open method.

1. *Simple retentive apparatus* may be employed in cases where the fragments are not widely separated, and can be readily brought into contact, and where the patient is not a good subject for operation.

A large piece of moleskin plaster is applied over the front and sides of the extensor surface of the thigh, reaching half-way up to the groin, and terminating below in two lateral elongated ends or tags, to which elastic traction is applied. The limb is placed on a back-splint, with a foot-piece, beneath which the elastic accumulator is firmly fixed. Removal of the effusion in the joint may be hastened by the use of the aspirator. At the end of about three weeks the patient is allowed to get about on crutches, with his knee in a rigid splint, which can be easily removed for daily massage and passive movements. At the end of five or six weeks active movements are permitted, and a special knee-splint is ordered (Fig. 254), which allows of only a small amount of mobility at first, but, by filing away a stop, this can be gradually increased, until a full range of movement is permitted. It is probable that only fibrous union is obtained by this method of treatment, but this is satisfactory and strong enough if the patient can give the time (6 to 12 months) to ensure its solidification. The strength of this fibrous union is best illustrated by the fact that if the bone gives way a second time, the lesion takes place through the bony, and not through the fibrous, tissue. When, however, the patient has to work for his living, it is essential that repair should be established at as early a date as possible, and this can only be secured by operative treatment.

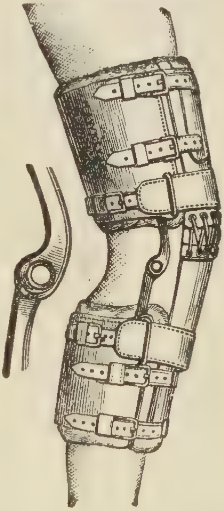

FIG. 254.—SPLINT FOR FRACTURED PATELLA.*

The steel joints at the sides are made with an *adjustable stop*, which prevents overstretching or rupture of the newly-formed bond of union.

2. To avoid the supposed risks of laying open the joint, various *subcutaneous operations* have been adopted. Of these the least objectionable is that recommended by Mr. A. E. Barker, who ties the fragments together by silver wire (Fig. 255). An opening is made with a tenotomy knife into the joint just below the lower segment, through which any effused blood or synovia can be squeezed, and along which a curved hernia needle is passed, traversing the articulation from below upwards, and emerging through the skin above the upper fragment. A piece of sterilized silver wire is then carried back under the bone. The needle is again inserted at the same spot below, and carried in front of the bone under the skin, emerging at the same point above. The upper end of the wire is threaded through it, and by this means brought out at the lower opening. The bone is thus encircled, and by tightening and twisting

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* For the loan of this block we are indebted to the late Mr. T. Hawksley, 357, Oxford Street, W

the wire the fragments are brought into apposition. The ends are cut off and pushed back under the skin. The limb is placed on a back-splint for a week or so, when passive movement is commenced, the patient being allowed to walk about at the end of the second week, and discarding all apparatus at the end of five weeks.

3. The *open plan of treatment*, advocated and perfected by Lord Lister, is undoubtedly the best, in that it permits of the removal of the tags of fascia and aponeurosis, which always intervene. It may be wise to delay operation for a few days in order that the joint may recover from the immediate effects of the injury.

A horseshoe-shaped flap is usually dissected up, exposing the fractured ends of the bone, which are cleared of all clot and fibrous shreds. Tracks for the wire sutures are now made by a drill, extending from the upper or lower end through the centre of the bone, so as to emerge on the fractured surface just in front of the articular cartilage (Fig. 256); should the drill emerge at different levels on the faces of the fragments, cartilage or bone must be chipped away to make a channel in which the wire may lie, so that the two fragments are exactly level, with no inequality of the articular cartilage. A sterilized silver wire of suitable thickness is then passed; the bones are brought into apposition, and the wire twisted into a knot or loop, which is hammered or pressed down into the tendinous or periosteal tissue over the upper fragment, so as to keep it from projecting under the skin and causing irritation. A second wire is sometimes needed in order to prevent rotation of the fragments. The wound is closed, and the limb kept on a back-

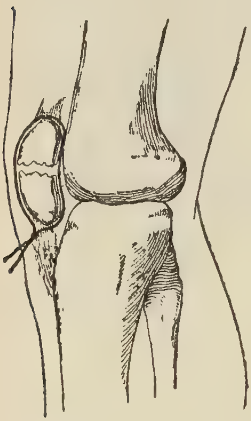

Fig. 255.—Barker's Method of Subcutaneous Suture for Fractured Patella.

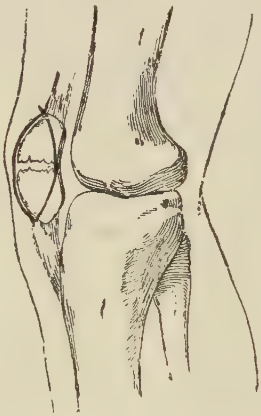

Fig. 256.—Lister's Plan of Suturing Patella by Open Operation.

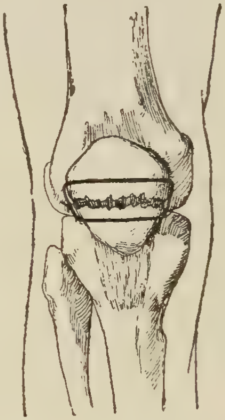

Fig. 257.—G. G. Hamilton's Method of Introducing Silver Wire for Fracture of Patella.

splint. In healthy adults passive movement may commence in ten days, and by the end of a fortnight the patient is allowed to walk in the simpler cases; but in complicated fractures and in elderly people it is better to keep the limb immobilized for a longer period.

It is sometimes wise to pass the wire transversely through the fragments (Fig. 257), as suggested by Mr. G. G. Hamilton, of Liverpool, a firmer and more secure hold being obtained in that way, and the wire being less likely to cut out.

In *old cases*, where the fibrous union has stretched and the utility of the limb is seriously impaired, operation holds out the only hope of helping the patient. The fibrous tissue must be dissected away, and the surfaces of the fragments freshened, if need be, with the saw, and drilled for the passage of the wire. To obtain apposition, the upper fragment must be detached from the femur, to which it is often adherent, and the rectus muscle, which is secondarily contracted, may need partial division. The limb should be well raised to relax the quadriceps and thus diminish tension on the bond of union, and lowered inch by inch on succeeding days. The muscle is thus stretched to accommodate itself to the altered conditions.

If the fragments cannot be brought absolutely together, the same treatment may be adopted, and the patient allowed to get about with a loop of silver wire between the fragments; the quadriceps is stretched by this means, and a subsequent operation may prove successful in gaining bony union.

Fractures of the Leg.

Fractures of the Tibia alone.—Several varieties are described. (*a*) The *upper end* is usually broken as a result of direct violence, the fracture being often comminuted. The characteristic features are not always very evident at first, since considerable swelling and ecchymosis are produced. Occasionally as a result of falls on the heel, a T-shaped fracture occurs, the tuberosities being broken off and the upper end of the shaft impacted into one or both of them. A few cases of vertical separation of one of the tuberosities alone are also on record. **Treatment** consists in placing the limb upon a back-splint, *e.g.*, Macintyre's, with the knee bent, and, as a rule, satisfactory union ensues, though possibly with some distortion. (*b*) Fracture of *the shaft* of the tibia, apart from the fibula, is usually caused by direct violence. It is transverse in the upper part of the bone, and oblique below. The fracture is diagnosed by feeling an inequality on running the fingers along the shin, together with pain at this spot on firmly grasping the bones above and below. There is often but little displacement, since the fibula acts as a splint, but the lower end of the upper fragment, which is usually pointed, is tilted forwards by the action of the quadriceps and may pierce the skin. The **Treatment** consists in the application of back or side splints (Cline's) for a few days until the swelling has gone down, and then the limb may be put up in plaster. If the bone has been comminuted, treatment will be more protracted. In some few cases reposition may be difficult owing to the character of the lesion, and operation may then be needed. Thus, in the patient whose fracture is represented in Fig. 191, although the limb had been immobilized in plaster of Paris, the fragments were not in apposition, and operative treatment was required. (*c*) The *internal malleolus* is occasionally separated as the result of direct injury, apart from any other osseous lesions, constituting what is known as 'Wagstaffe's fracture.' There is comparatively little displacement, but the malleolus is loose, and crepitus can usually be obtained on moving it backwards and forwards. Union by fibrous or osseous tissue ensues, but usually in a more or less abnormal position, in consequence of which the integrity of the ankle-joint is disturbed, and weakness or lameness may follow. **Treatment** consists in securing the fragment into position by screw or nail; otherwise massage and the application of lateral splints must be relied on.

Schlatter's Disease.—This term is applied to an affection of the upper end of the tibia in young people, the nature of which is a little doubtful. Probably it is due to a partial separation of the lower tongue-shaped prolongation of the upper epiphysis, which forms the tubercle of the tibia, and this is followed by a subacute inflammation. The child complains of a tender swelling in this region without any affection of the joint, and walks with a limp. The part requires to be kept at rest, and will in time get well. Radiography suggests a displacement forwards of the epiphysis, but operative treatment is not desirable.

Fractures of the Fibula alone are by no means uncommon, usually occurring as a result of direct violence. There is no displacement or deformity; but the patient complains of pain localized to some particular spot, and this can usually be elicited by grasping the bones above and below, and compressing them laterally (' springing ' the fibula). Radiography will make the diagnosis clear. **Treatment** consists in immobilizing the limb in a plaster case.

Fracture of both Tibia and Fibula is a very common accident, due to both direct and indirect violence; if to direct violence, any part may be injured, both bones yielding at the same level; but if in consequence of an indirect injury, the tibia usually gives way at its weakest part, viz., at the junction of its middle and lower thirds, and the fibula at a slightly higher level. The fractures are often oblique, running in any direction, although the obliquity is most frequently directed downwards, forwards, and inwards. The lower fragment is generally drawn upwards on account of the contraction of the powerful calf muscles, and often rotated outwards from the weight of the foot; hence there is well-marked shortening. The ordinary characteristics of a fracture are very evident, and but little difficulty can ever be experienced in making a diagnosis. The fracture is likely to become compound when due to indirect violence, owing to the sharp end of the upper fragment of the tibia piercing the skin.

The fracture of the tibia has been proved by radiography to be frequently of a spiral character, and is then probably always due as much to forcible torsion of the limb as to vertical strain. The rotation is an important element, and the shortening is sometimes less marked than in simple oblique fractures; there is frequently some difficulty in getting satisfactory approximation of the fragments, even on operation, owing to the broken ends becoming engaged in the fibro-muscular tissues around.

Treatment.—In the simpler cases reduction is accomplished by flexing and fixing the knee, so as to relax the muscles of the calf, and then making traction on the foot and manipulating the parts into position. The tendo Achillis may, if necessary, be divided. It will usually suffice to put up the limb in side-splints, such as Cline's, the longer one with the foot-piece being intended for the outer side. In other cases it may be better to apply a broad posterior splint with a rectangular foot-piece, *e.g.*, Macintyre's or Neville's, and two lateral splints; or the old-fashioned half-box splint may be employed. Whatever treatment is adopted, it is necessary to see that the length of the limb is as far as possible maintained, and that no rotation of the lower fragment is present. To ensure absence of rotation, all that is needed is to note that the inner aspect of the great toe, the

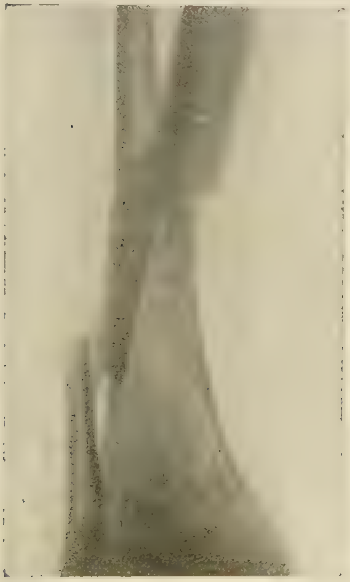

FIG. 258.—FRACTURE OF BOTH BONES OF THE LEG, SEEN FROM IN FRONT.

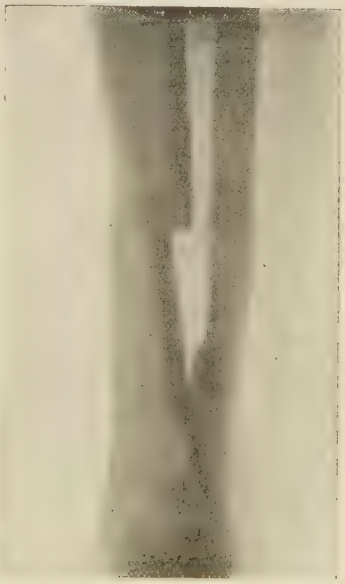

FIG. 259.—THE SAME FRACTURE AS IN FIG. 258, SEEN FROM THE INNER SIDE.

From a study of the two radiograms it will be noticed that both lower fragments have been displaced outwards, with but little alteration in their antero-posterior axes.

subcutaneous surface of the internal malleolus, and the inner border of the patella, are in the same line, and correspond with the opposite limb. Union will be sufficiently advanced in two or three weeks at the latest to allow of the limb being put up in a removeable plaster casing, which must be taken off daily for purposes of massage, but in spite of this much subsequent lameness is the usual result. In oblique and spiral fractures there is often very great difficulty in getting the fragments together, and even more in maintaining them in good position. Taking into consideration the degree of permanent depreciation that a man (especially if of the labouring classes) suffers from vicious union of these bones, surgeons need now have no hesitation in cutting down on and fixing any fracture of the tibia and fibula which is determined by radiography to be oblique or spiral in nature and with well-marked displacement.

Fractures in the neighbourhood of the Ankle-joint are usually produced by indirect violence, the foot slipping, and leading primarily to a displacement of the ankle, the fracture being a secondary result. They would therefore be better described as **Fracture-dislocations at the Ankle-joint.**

1. *Displacement of the Foot outwards* is by far the most common variety, resulting usually from the patient slipping on the inside of the foot, as from off a kerbstone. Several distinct varieties of lesion are now recognised.

(*a*) In *Pott's Fracture* (Fig. 260) sudden abduction, usually combined with eversion, of the foot results in severe strain upon the internal lateral ligament, which gives way, or the base of the internal malleolus is torn off. The astragalus is at the same time driven outwards against the external malleolus, and the force is thence transferred up the fibula, which bends and breaks at some weak spot. Generally the line of fracture runs obliquely from above downwards and forwards through the malleolus; less frequently it is situated in the position originally described by Pott, viz., about three inches above the tip of the malleolus, and is transverse, the upper end of the lower fragment being displaced inwards towards the tibia. The inferior interosseous tibio-fibular ligament remains intact, and hence the foot itself is merely rotated outwards and abducted, and the heel is drawn upwards, whilst the toes point downwards. If the internal lateral ligament alone is torn, the malleolus projects beneath the skin, and may, indeed, protrude; if the malleolus is broken, a distinct sulcus can usually be felt between it and the lower end of the tibial shaft. In both these types the ankle-joint is necessarily laid open, and there is probably much hæmorrhage on the inner side of the ankle and into neighbouring tendon sheaths.

(*b*) In *Dupuytren's Fracture* (Fig. 261) a much more serious lesion is produced. The interosseous tibio-fibular ligament yields more or less completely, or the flake of the tibia to which it is attached is torn off; the foot, carrying with it the lower portion of the fibula and the superficial flake of the tibia, which has been detached, is displaced firstly outwards, and so long as the upper surface of the astragalus does not clear the lower articular surface of the tibia, there is merely lateral displacement with marked abduction of the foot and increased breadth of the ankle. Should the force continue to act, the astragalus may be carried sufficiently outwards to clear the lower end of the tibia, and then an upward and to a less degree a backward displacement is added, causing great eversion of the foot and deformity of the ankle. On the inner side either the ligament or the malleolus may yield.

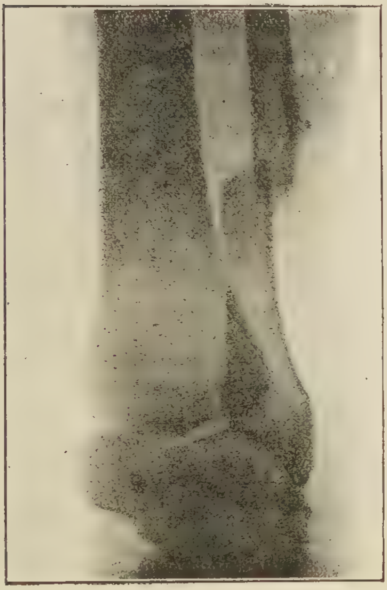

FIG. 260.—POTT'S FRACTURE, SHOWING SEPARATION OF INTERNAL MALLEOLUS AND FRACTURE OF FIBULA.

(For the loan of the negative from which this plate was prepared, we are indebted to Mr Caldwell, of Mandeville Place, W.)

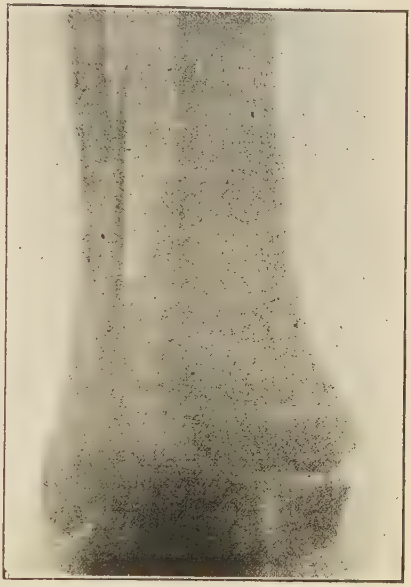

FIG. 261.—DUPUYTREN'S FRACTURE, WITH WELL-MARKED DISPLACEMENT OUTWARDS OF THE FOOT, AS WELL AS OF THE LOWER FRAGMENT OF THE FIBULA AND THE INTERNAL MALLEOLUS. (RADIOGRAM TAKEN FROM IN FRONT.)

(*c*) In another variety the injury consists in the usual type of fracture of the fibula, associated with an almost transverse fracture of the tibia, just above the base of the inner malleolus. In this form the lower end of the shaft of the tibia projects beneath the skin, and is likely to be mistaken for the tip of the malleolus; if this error is committed, and the fracture allowed to unite without proper rectification, considerable deformity results.

(*d*) A similar injury in children may produce a separation of the lower epiphysis of the tibia, whilst the fibula yields in the usual situation. The line of separation in the tibia is more or less transverse, but may extend into the diaphysis on the outer side.

In almost all of these varieties the ankle-joint itself is involved, and this, combined with the amount of bleeding that occurs into tendon sheaths and muscles around, and the difficulties sometimes experienced in complete reduction of the fracture, explains why the results of these cases are frequently so unsatisfactory. Sometimes after union has occurred, pain and deformity become increased, owing to the patient being allowed to walk too early, the result being that the callus yields to the weight of the body. Should union occur with the foot in a false (*i.e.*, everted) position, a large mass of callus develops between the shaft of the tibia and the malleolus.

2. *Displacement of the Foot inwards.*—When the patient slips on the outer aspect of the foot, the astragalus is forcibly driven against the inner malleolus, which may be broken off or impacted into it. The outer malleolus is dragged inwards with the foot, and owing to the integrity of the inferior tibio-fibular ligament, which acts as a fulcrum, the fibula yields at the same spot as in Pott's fracture. The foot is displaced inwards, and perhaps slightly backwards.

3. *Displacement of the Foot backwards,* by catching the heel and tripping forwards, is usually associated with fractures of the tibia and fibula in the same position as in Pott's fracture, but eversion of the foot is absent (see dislocation of the ankle backwards, p. 625).

Treatment.—In reducing these fractures, traction should be made upon the foot after the tension of the calf muscles has been relieved by flexing the knee under an anæsthetic, or by tenotomy of the tendo Achillis; the position of the internal malleolus must be accurately defined. Before applying the splints, careful attention must be given to the following points: (*a*) The foot must be maintained at right angles to the leg; (*b*) the heel must not project unduly backwards; and (*c*) the foot must not be rotated on the leg—*i.e.*, the inner surfaces of the great toe, internal malleolus, and patella must be in the same line. A pair of Cline's splints is often sufficient to steady the parts in simple cases, and must be applied with sufficient firmness to keep the malleoli together and prevent subsequent lateral play in the ankle-joint. Some patients are better treated, however, by a Dupuytren's splint (Fig. 262), which is really a Liston's splint on a small scale. It reaches from the knee to below the sole of the foot, and is placed on the inner side of the limb, the patient lying on the sound side during its application. A firm pad extends down as far as the base of the internal malleolus, and over this as a fulcrum the foot is drawn inwards by a handkerchief applied around the ankle, and tied to the notches at the end of the splint. The foot being thus fixed, the upper end of the splint is bandaged to the limb. Marked tendency to backward displacement of the heel may be counteracted by the application of a Syme's anterior horseshoe splint, which can be used in combination with a Dupuytren. It consists of a flat piece of wood, well padded, extending from the knee to the ankle along the crest of the tibia; the lower end is shaped like a horseshoe, the two limbs passing one on either side of the foot. A handkerchief or piece of bandage is applied, with its centre over the point of the heel; it passes up on either side between the splint and the foot, winds over the former structure, and is tied behind the heel, which is thus lifted forwards. A similar end may be obtained by the use of a Macintyre's back-splint combined with a pair of Cline's splints.

At the end of ten days or a fortnight, when all tendency to displacement has ceased, these splints may be discontinued and lateral poroplastic or plaster of Paris splints applied, so that they may be removed daily for massage and suitable movements. Even when fit to walk, considerable after-care is needed to prevent harm arising from the weight of the body. In many cases it suffices to thicken the sole of the boot on the inner side so as to maintain the foot in a position of slight varus; in worse cases an outside iron should be worn, passing down from a circular band below the knee to be fixed in a slot in the sole of the boot.

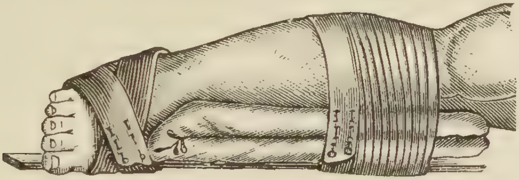

FIG. 262.—DUPUYTREN'S SPLINT APPLIED FOR POTT'S FRACTURE. (TILLMANNS.)

In the simpler forms, early massage may be employed, and then all the retentive apparatus necessary is a light removeable plaster case. In the more serious cases, where there is considerable displacement and much difficulty in keeping the fragments together, operation to fix them is quite justifiable.

In cases of vicious union after Pott's fracture, it is usually necessary to re-divide the fibula, and to excise a **V**-shaped portion of bone from the tibia, perhaps extending into the ankle-joint, so as to enable the malleolus to be brought in contact with the shaft.

Fracture of the Os Calcis may result from direct violence, such as a blow or fall on the heel, or possibly from muscular action, the epiphysis being then separated, or the shell of bone into which the tendo Achillis is inserted being torn off. The fragment thus separated is displaced upwards by the contraction of the calf muscles, and the resulting deformity is very evident. If the line of fracture passes through the body of the bone, there may be no displacement, owing to the attachment of the interosseous and lateral ligaments; but should the sustentaculum tali or greater process be broken, the arch of the foot may be more or less flattened. When due to a fall from a height, the bone is often comminuted and the foot much bruised and swollen (*compression fracture*). **Treatment** consists in immobilizing the foot in a plaster case if there is no displacement; but where the posterior part of the bone is drawn upwards, it must be approximated to the rest of the bone after flexing the leg, in order to relax the calf muscles, or possibly after tenotomy. A more satisfactory result may, however, be obtained by cutting down, and wiring or pegging. In fractures which are likely to be followed by traumatic flat foot, the patient must not be allowed to walk without an effective support, and the foot must be maintained in a slight varus position.

Fracture of the Astragalus is usually due to falls on the foot from a height, or from direct violence applied to the foot, as by a weight falling upon it. The lesion is often a severe comminuted one, and portions of the bone may be displaced forwards or backwards, making a marked projection beneath the skin. Such accidents are often associated with lesions of the tibia or fibula, and possibly even of the femur. The whole region of the ankle becomes infiltrated with blood, and an exact diagnosis is sometimes difficult. **Treatment** consists either in immobilization, which is likely to be followed by stiffness of the ankle, or in bad cases by excision of the bone or of projecting fragments.

Occasionally in less severe accidents the bone merely splits across, the lesion being usually situated about the neck. Such is due either to the weight of the body flattening out the arch of the bone beyond the limits of elasticity, or, if the foot is dorsi-flexed, to penetration of the bone by the anterior edge of the tibia, impaction being sometimes produced in this way. Massage and early mobilization should be employed in such cases.

Other bones of the foot are occasionally fractured, but these lesions require no detailed description.

CHAPTER XXI.

DISEASES OF BONE.

Inflammation of Bone.

General Considerations.—Bones are divided into the long, the short, and the flat, each of these consisting of compact and cancellous tissue. In the short bones there is but a thin layer of compact tissue surrounding a cancellous central mass, the meshes of which are filled with medullary fat and connective tissue. In the flat bones the compact tissue forms two limiting plates, separated by a layer of cancellous tissue (known in the skull as the diploë). In long bones the shaft consists of a tube of compact structure, surrounding a space which is normally filled with medulla, and known as the medullary canal; at each end it gradually merges into a larger mass of loose cancellous tissue, the interstices of which are similarly packed with vascular fatty medulla, which apparently performs the function not only of maintaining the nutrition of the bone, but also of elaborating the blood. Prolongations from the medulla extend into the Haversian canals, and are thence continuous with the periosteum, so that the mineral skeleton has incorporated within it a vascular fibro-cellular mass which permeates its whole structure.

The *vascular supply* of a bone is derived (*a*) from the nutrient artery which passes into the medullary space, and there breaks up into branches which ramify through the whole of the medullary tissue, and thence extend into the Haversian canals; and (*b*) from the periosteum, an exceedingly vascular ensheathing membrane, from which small vessels pass perpendicularly into the Haversian canals, and establish a communication between the two systems. These latter vessels are especially numerous and large close to the epiphyses. Large veins occur in the medullary and cancellous interior, and are frequently thrombosed in inflammatory mischief; if the thrombus becomes infected, and so disintegrated, pyæmia is very likely to ensue.

The *growth* of bone manifests itself in three different directions: (i.) It increases in length from the shaft side of the epiphyseal cartilage, the epiphysis itself growing but little. In the upper limb the chief increase in length occurs at the shoulder and wrist, whilst in the leg it is mainly evident on either side of the knee-joint, and this in spite of the fact that the so-called nutrient arteries are directed away from these points. (ii.) Increase in breadth is produced by new formation under the periosteum. There has been much difference of opinion as to whether this membrane has any true bone-forming power. That bone is often formed from it when stripped up is undoubted; but it is probable that the angular nucleated osteoblasts found on its under surface have been derived from the bone itself by the process of detachment, which necessarily tears through or drags out the vessels which pass from the periosteum into the bone. (iii.) A bone increases in density by a new deposit of osseous tissue around the Haversian canals and cancellous spaces.

In considering the inflammatory affections of bones, it must always be kept in mind that the essential pathological phenomena (viz., hyperæmia, exudation, and tissue changes) are similar to those manifested in any other vascular structure, but that the effects are modified by the limited space in which the vessels lie, and the resisting character of the surrounding osseous tissue. Hence any *acute* inflammation, associated with rapid vascular engorgement and considerable exudation quickly poured out, leads to *necrosis* from thrombosis, due to increased pressure within the unyielding bony canals. If, however, the process is *subacute*, so that the tissue-liquefying properties of the exudation and the tissue-absorbing activity of the leucocytes can come into play, then *osteo-porosis* or *rarefaction* of the bone follows, a condition sometimes termed *caries*. On the other hand, if the inflammation is *chronic*, and due to causes other than tubercle or the pressure of tumours, then new formation occurs, and *osteo-sclerosis*, or condensation, is most likely to result. Tubercle in bones, as elsewhere, causes primary rarefaction of the tissue attacked, though sclerosis may be associated with or follow it, and the chronic pressure of tumours or aneurisms leads to local rarefaction and atrophy, although a certain amount of sclerosis may be induced around.

Much needless confusion has arisen in connection with the *terminology* of inflammatory affections of bone. To all of them, whatever their nature or position, the term ' osteitis ' might rightly be applied; but when the medullary cavity of a long bone is particularly affected, the term ' osteo-myelitis ' is substituted, as also sometimes when masses of cancellous tissue, as in the os calcis, or sheets of it, as in the diploë of the cranial bones, become the seat of an acute inflammation. The vascular continuity between the periosteum and medulla through the Haversian canals will explain why periostitis is always associated with osteitis of the underlying bone, and why osteomyelitis is never strictly limited to the medullary cavity.

It is also important to realize that necrosis, caries, and sclerosis are **results** of inflammation, and must neither be confounded with the pathological processes leading to them, nor described as distinct diseases.

Necrosis, or death of bone, may occur in a variety of forms, and from many different causes, *e.g.*: (*a*) From acute localized suppurative periostitis, the sequestrum or dead mass being then simply a superficial plate or flake of the compact exterior (Fig. 263), the process by which it is cast off being then known as 'exfoliation'; (*b*) from acute infective osteo-myelitis, the sequestrum then often involving the whole thickness of the bone, and invading more or less of the length of the diaphysis, if the condition is not early and efficiently treated (Figs. 265 and 266); (*c*) from acute or subacute infective osteitis of cancellous bone, the sequestra being small spiculated fragments of the bony cancelli which have escaped absorption by the granulation tissue always forming in such a process; (*d*) from tuberculous disease of cancellous tissue, the sequestrum being light and porous, often infiltrated with curdy material, and rarely separated completely from surrounding parts (Fig. 273); (*e*) from syphilitic disease of cancellous or compact tissue, usually resulting from excessive sclerosis, or gummatous disease of the periosteum which has become septic (Fig. 276); (*f*) from the action of local irritants, *e.g.*, mercury, or phosphorus fumes gaining access to the interior of the teeth; (*g*) occasionally as a simple senile loss of nutrition, as in senile gangrene; and (*h*) a variety, described by Sir James Paget under the name of 'quiet necrosis,' occurs as a result of direct injury, the sequestrum separating without suppuration; it is one of the causes of loose bodies in joints, and especially the knee, following a blow on one of the condyles.

The presence of dead bone in a limb may be suspected when one or more sinuses are present, discharging pus or serum according to circumstances, with puffy granulations pouting round the opening, and the underlying bone thick and enlarged. A probe passed down the sinus can usually be made to strike against the sequestrum, perhaps after passing through a casing of new bone, and its fixity or freedom may be demonstrated in this manner.

Caries, or, as it is sometimes called, *osteo-porosis* or *rarefaction of bone,* is characterized by a soft and spongy state of the bone, which, if it can be reached, readily breaks down on pressure with a probe. It may result from the following conditions: (*a*) A simple subacute inflammatory process, *e.g.*, during the early stage of repair in a fracture; (*b*) from acute or subacute infective inflammation of cancellous tissue; (*c*) from tuberculous affections of the cancellous tissue or periosteum; (*d*) from syphilitic disease of the medulla or of the under surface of the periosteum.

Pathologically, it is characterized by the replacement of the medulla by granulation tissue, which usually contains some large multi-nucleated cells, or *osteoclasts*, and these seem to be closely connected with the removal of the bone. The cancellous tissue becomes hollowed out to accommodate these granulations, and the osteoclasts are usually found occupying shallow depressions known as 'Howship's lacunæ.' In tuberculous and syphilitic lesions the bone corpuscles often undergo fatty degeneration.

Caries may occur with or without suppuration (*C. sicca* or *suppurativa*); sometimes the development of granulation tissue is excessive, as when it fungates into a joint (*C. fungosa*). Not unfrequently it is associated with necrosis, constituting a condition of *cario-necrosis* (or *C. necrotica*), as in infective inflammation of cancellous bone, minute spiculated sequestra being found in the discharge, whilst in tuberculous osteitis dead portions of larger size often occur. In fact, caries and necrosis bear much the same relation to one another as ulceration and gangrene of the soft tissues.

If caries is recovered from, a subsequent condition of sclerosis usually follows, with loss of substance and often deformity.

Sclerosis of bone (osteo-sclerosis) is invariably the result of some chronic inflammatory affection, *e.g.*, (*a*) chronic periostitis, whether simple or syphilitic; (*b*) chronic osteo-myelitis, simple, tuberculous, or syphilitic; or (*c*) chronic osteitis of the compact bone, which is always secondary to one of the former. In all cases the condition is due to a slow formation of new bone within the Haversian canals or cancellous spaces, thus diminishing their lumen; in syphilis this may progress to such an extent as to lead to their total occlusion, and even to localized necrosis from lack of blood-supply, especially when sepsis has occurred. In tuberculous bones the sclerosed tissue is always at some distance from the focus of mischief, and may be looked on as Nature's attempt to limit the spread of the disease; it forms also the final tissue or bone-scar in the process of repair in those cases where a cure has been obtained by natural or surgical means.

Classification of Inflammatory Affections of Bone.

I. **Periostitis :**
  (*a*) Acute localized, with or without suppuration.
  (*b*) Acute diffuse, always associated with or secondary to acute infective osteo-myelitis.
  (*c*) Chronic simple, or hyperplastic.
  (*d*) Chronic tuberculous.
  (*e*) Chronic syphilitic.

II. **Osteitis of compact bone,** which is always associated with and secondary to either periostitis or osteo-myelitis, and so need not be described separately. The acute form results in necrosis, the subacute in osteo-porosis, and the chronic in sclerosis, except in tuberculous disease.

III. **Osteo-myelitis,** or inflammation of the medulla of long bones:
  (*a*) Acute infective.
  (*b*) Subacute simple or infective, *e.g.*, during the separation of sequestra, resulting primarily in rarefaction, but finally in sclerosis.
  (*c*) Chronic simple, tuberculous or syphilitic, usually causing general enlargement and sclerosis of the bone, even if locally some rarefaction is present.

IV. **Osteitis of Cancellous Tissue** may similarly be:
  (*a*) Acute infective.
  (*b*) Subacute simple or infective.
  (*c*) Chronic simple, syphilitic, or tuberculous.

When limited to the articular end of a bone in a young person, this is sometimes termed **Epiphysitis**; this title is also sometimes applied erroneously to an acute osteomyelitis, which commences in the vascular tissue on the shaft side of the epiphyseal line.

It is unnecessary to describe in detail all these conditions, since many of the divisions overlap, and hence we shall group together the various acute and chronic affections.

Acute Inflammations of Bone.

1. **Acute Localized Periostitis** usually arises as a result of traumatism applied directly to the bone, with or without an open wound; it may also be determined by rheumatism, or by an extension of inflammatory mischief, as in an alveolar abscess.

Pathologically, the process consists of hyperæmia of and exudation into the periosteum, which becomes swollen, turgid, and thickened. This may be followed in due course by resolution, or may leave the bone thickened and in a condition of chronic inflammation; or suppuration may ensue, and with it usually a limited superficial necrosis. In the last event pyogenic organisms of no great virulence find an entrance to the area of mischief, and probably in cases due to trauma through the abraded or injured skin; in other instances they may come from neighbouring foci of inflammation, or possibly from the blood. The inflammatory process extends to the small vessels entering the bone from the under surface of the periosteum; these become dilated, next thrombosed and strangled by the pressure of the exudation around them, and finally pulled out from the osseous canals by the tension of the subperiosteal effusion. Consequently, the vitality of the superficial layer of bone is destroyed for an area corresponding almost exactly to that from which the periosteum has been stripped (Fig. 263, A).

As soon as tension has been relieved by the escape of the pus, repair commences. Where the mischief is slight and superficial, the involved bone may entirely recover, necrotic portions being absorbed, if the surrounding parts are sufficiently vascular. If the dead portion of bone is compact and more extensive, it will be separated from the subjacent living tissues by one of the processes already described (p. 109), whilst from the under surface of the stripped-up periosteum a casing of new bone is developed, constituting an *involucrum* or sheath, at first spongy and cancellous in texture, but finally hard and sclerosed. In the centre of this new formation are found one or more openings or *cloacæ* through which the discharge passes, and corresponding in position to the apertures in the periosteum and skin made for the escape of the pus (Fig. 263, B).

Clinically, the symptoms of acute localized periostitis consist in the ordinary phenomena of acute inflammation, the pain being of an intense aching character, worse at night, and increased by lowering the limb or by any kind of pressure. If a subcutaneous portion of bone is involved, a painful swelling develops, at first brawny in character, but when suppuration has occurred the centre softens whilst the skin over it becomes red and œdematous. When an abscess has burst or been opened, bare bone is felt beneath the periosteum, and the greater part of this denuded structure usually dies, and must then be either absorbed or separated; in either case a sinus remains for a time, leading down through a cloaca in the involucrum to the sequestral cavity. From this either pus or serum will be discharged, according to whether the wound has become septic or not. In about five or six weeks' time the sequestrum is loose, and this may be ascertained by moving it with a probe within the osseous cavity, which is now lined on the inner aspect with granulation tissue.

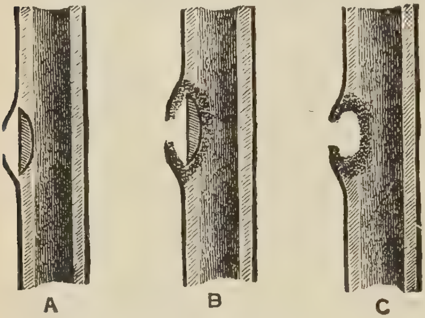

Fig. 263.—Superficial Necrosis resulting from a Localized Periostitis (Diagrammatic).

A represents the necrosed tissue lying in continuity with the surrounding living bone; the periosteum is stripped up from it, and has an opening through which the pus has been discharged. B shows a later stage, in which the sequestrum is being separated by a process of rarefying osteitis in the immediately contiguous living bone, whilst an involucrum, or sheath of new bone, is formed from the under surface of the periosteum; a cloacal aperture remains in the involucrum for the escape of discharges. C shows the condition of affairs after the sequestrum has been removed.

Treatment.—Rest, elevation of the limb, and fomentations are usually relied on locally in the early stages, and favourable reports have been given as to the value of Bier's induced hyperæmia. If, however, the affection is not readily checked, and suppuration threatens or develops, a free aseptic incision down to the bone is the best means of preventing or limiting necrosis. When necrosis has occurred, the parts must be carefully dressed and kept aseptic, until the sequestrum is absorbed or set loose. In the latter case an incision is made over the involucrum, the periosteum stripped from it, one of the cloacæ enlarged, and the dead bone removed. The cavity will then rapidly fill up and heal by granulation.

2. **Acute Infective Osteo-Myelitis** (*syn.:* **Acute Necrosis, Acute Diffuse or Infective Periostitis, Acute Diaphysitis, Acute Panostitis**).—This disease usually occurs in children, often of a tuberculous inheritance, and not unfrequently follows one of the exanthemata—*e.g.*, measles or scarlet fever. It generally commences before the age of puberty, and is an affection of the gravest import; the multiplicity of names attached to it suggests quite accurately that its manifestations may be very diverse in character.

Pathology.—The patients are always in a state of depressed general health, so that their germicidal powers are considerably diminished.

Moreover, spots of localized ulceration are often present in the throat, mouth, or intestines, which give a ready entrance for micro-organisms into the system. Evidently some of these must be circulating within the blood, ready to attack any area of diminished tissue resistance. A slight injury in the shape of a strain or a wrench, which is often entirely overlooked, may suffice to determine the commencement of an inflammatory process which rapidly spreads, until perhaps the whole bone is affected.

The majority of the ligaments and not a few tendons are inserted into the epiphysis, and hence articular strain must be mainly felt in the juxta-epiphyseal region, *i.e.*, immediately beyond these insertions. It has been already mentioned that the traumatic separation of epiphyses is liable to be followed by suppuration, even in healthy children, and it is easy to understand that in an unhealthy child a very slight injury in the epiphyseal region may determine a similar process.

The disease almost always starts in the soft vascular tissue on the shaft side of the epiphyseal cartilage, but occasionally in the epiphysis itself, and in a few instances (mainly amongst young adults) it may be preceded by a patch of localized periostitis, suggesting that an acute infection has supervened upon a subacute periosteal focus. The nature and extent of the inflammatory phenomena depend largely on the exact situation of the infective focus, the amount of resistance offered by surrounding tissues, and the virulence of the organisms. As in any other part of the body, the trouble is most likely to travel along the line of least resistance.

(1) If the process commences in the periphery of the juxta-epiphyseal region close to the periosteum, the line of least resistance will be towards that structure, and hence a *subperiosteal abscess* may form, whilst the central portions of the bone may escape almost entirely. The size of this abscess varies, but considerable portions of the diaphysis may be denuded, resulting in extensive necrosis. It rarely spreads to the neighbouring joint, owing to the close bond of union which exists between the diaphyseal periosteum and the epiphyseal cartilage. In this variety an early incision to let out the pus may suffice to prevent necrosis, or, at any rate, to limit it. The constitutional symptoms will be less severe than in other varieties; there is less likelihood of the development of pyæmia, and the toxic fever soon disappears after the removal of the pus. Subsequently the same course of events occurs as in the localized variety of acute periostitis—viz., an involucrum forms, perforated by one or more cloacæ, and the sequestrum in time separates.

A good illustration of this type is to be found in the acute periostitis which affects the *lower end of the femur*. It almost always starts posteriorly, stripping the thin periosteum off the back of the bone as far as the bifurcation of the linea aspera. Its preference for this situation is evidently due to the fact that strains upon the knee-joint are mainly experienced when the limb is hyper-extended, and that such strain is directed to the posterior ligaments, and hence the posterior portion of the epiphyseal line is likely to suffer. Suppuration follows, and if not recognised and treated early, may burst through the thin periosteum and be widely diffused under the quadriceps. The involucrum in this affection is often defective behind.

(2) Should the process start in the centre of the juxta-epiphyseal region, it may spread in several directions, and the results vary considerably.

(*a*) The process may reach the periosteum first, and then the phenomena of a diffuse subperiosteal abscess, as indicated above, with the addition of the symptoms due to its deeper origin, will manifest themselves. This is, perhaps, the most usual course for the disease to take.

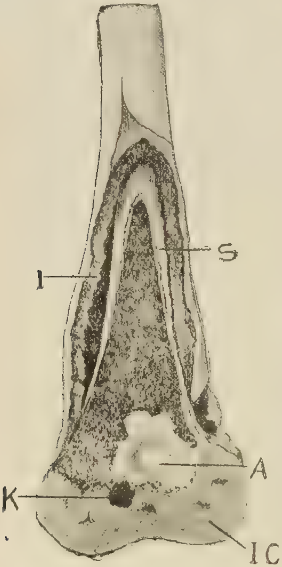

Fig. 264.—Acute Osteo-Myelitis of the Lower End of the Femur in a Child of Nine Weeks. (After Lexer.)

IC, Internal condyle; K, centre of ossification in epiphysis; A, abscess cavity in epiphyseal line; S, sequestrum; I, involucrum.

(*b*) If the infection extends along the medullary cavity, the most typical form of osteo-myelitis ensues (Fig. 264). The medulla becomes intensely hyperæmic; the veins are thrombosed; localized foci of suppuration and gangrene appear; and in consequence of the increased pressure infective emboli are likely to be detached and pyæmia to follow. Even if the latter does not supervene, the general condition is profoundly affected by the absorption of toxins. Suppuration also occurs beneath the periosteum, although the amount of pus may not be great at first; but the membrane is stripped up from the diaphysis, perhaps to such an extent as to involve the whole length and circumference of the shaft. Unless prompt measures are taken to limit the progress of the disease, necrosis is certain to follow, usually implicating the whole thickness of the diaphysis, and sometimes its whole length; in fact, the diaphysis is occasionally found lying loose in an abscess cavity, the two epiphyses having been detached. A similar result is sometimes due to the trouble starting at each end of the diaphysis. As a rule the epiphysis, even though detached, retains its normal position; but sometimes it becomes displaced, and then deformity of the limb results.

(*c*) It has been already mentioned that, owing to the intimate connection between the periosteum of the diaphysis and the epiphyseal cartilage, the neighbouring joint usually escapes infection, although it is often the site of a sterile synovial effusion. Should, however, the epiphyseal line be within the joint, as in the hip, it must perforce become the seat of an acute infective arthritis as soon as the bacteria reach its periphery. The elbow-joint is similarly liable to suffer when bacteria attack the upper end of the ulna, since the epiphysis is a mere flake of bone, and the greater part of the olecranon is derived from the shaft. Sometimes the junction cartilage is softened and destroyed by the organisms, so that the inflammation spreads through the epiphysis to the articular cartilage, which is eroded, and the joint opened. Occasionally the pus burrows along the soft tissues outside the bone, as along the biceps groove into the shoulder-joint.

In infants, where there is little or no bone, the cartilage may be rapidly destroyed, and an opening made through it into the joint, giving rise to what was described by the late Sir Thomas Smith as the acute arthritis of infants.

(*d*) When the organisms are of a less virulent type, the process may be much more localized and subacute in nature, resulting in a limited central necrosis, or in a chronic abscess inside the bone (*Brodie's abscess*) if the part involved consists of a mass of cancellous tissue, as in the head of the tibia. A similar condition may affect certain epiphyses which occur away from joints, and some chronic abscesses in such situations as the great trochanter may be explained on these grounds. A chronic abscess of this nature may exist for many years, and cause much thickening of the surrounding bone from sclerosis. Gradually, but as a rule very slowly, the cavity increases in size and may burrow, finally opening into a joint or beneath the periosteum.

Another occasional result of a subacute non-suppurative osteomyelitis is bending of the affected bone, especially if the patient is able to put any pressure or weight on it.

(3) In the flat bones, such as the innominate, scapula, and those of the cranium, the cancellous tissue becomes filled with pus, and owing to the abundant supply of veins pyæmia is very likely to develop. Abscesses may form on both sides of the bone, and a larger extent of necrosis may result. In the skull a subcranial abscess (p. 764) may develop, and possibly be complicated by a true abscess in the brain.

The *organism* generally found in this disease is the *Staphylococcus pyogenes aureus*, but occasionally others are responsible for it, and the symptoms vary somewhat with the causative microbe. Thus, if due to the *Staph. pyog. albus*, the process is less acute; a good deal of brawny infiltration of the periosteum ensues, and necrosis is more easily prevented by early treatment; this variety is sometimes termed 'periostitis albuminosa.' The *Streptococcus pyogenes*, if present at all, is only found in young children, and the resulting necrosis is often less extensive. The *Pneumococcus* has also been frequently discovered in this disease in children, as well as the *B. coli*, which latter only occurs in association with other organisms; the resulting pus is very foul.

Clinical History.—The disease usually commences abruptly with a rigor, followed by high fever and severe pain in the limb, which soon becomes swollen, brawny, and congested. It may be mistaken for an acute attack of rheumatism, although the fact that the inter-articular portion is affected, and not the joint, should prevent this error. The pain is of an extremely severe nature, so that the child screams whenever the limb or even the bed is touched.

Should the trouble be mainly limited to the periosteum, evidences of its being stripped off the bone, and of the accumulation of pus beneath it, soon show themselves. An abscess forms which may quickly transgress its periosteal boundary and burrow under fascial or muscular planes; its limitation to the diaphysis has been already explained; but, although the neighbouring joints may escape infection, they are very likely to suffer from a serous exudation, and subsequently some restriction of movement may be observed. Sooner or later the abscess bursts or is opened, giving exit to a larger or smaller quantity of pus, and the subjacent bone is found bare and apparently dead. Possibly the relief of tension may suffice in such cases to limit the mischief, the periosteum again becoming adherent

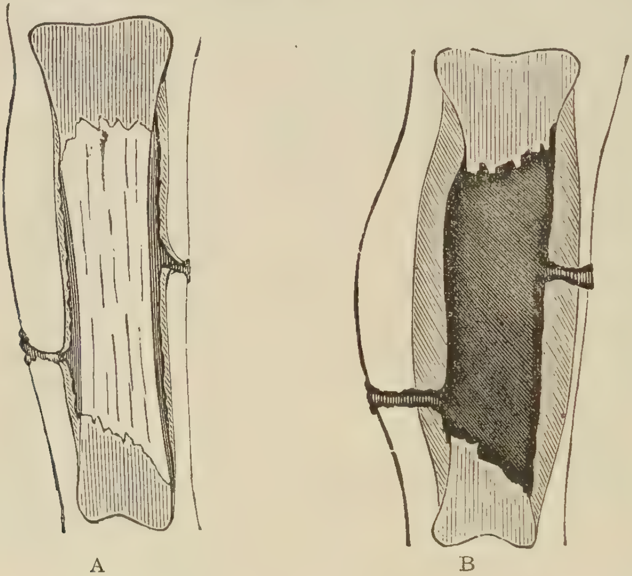

FIG. 265.—DIAGRAM OF MASSIVE NECROSIS AFTER ACUTE OSTEO-MYELITIS (BILLROTH.)

In A (early) the necrosed tissue, though continuous above and below with the healthy bone, is surrounded by a cavity formed by the stripping up of the periosteum, and from it two sinuses pass to the exterior; in B (late) the sequestrum is supposed to have been loosened and removed, and the cavity remaining is lined by granulation tissue, and surrounded by a thick involucrum of new bone, in which the two cloacæ still persist.

to the bone, and a cure being established without extensive necrosis. More frequently a considerable portion of the shaft loses its vitality and has to be separated in the manner already described, whilst an involucrum forms around it from the periosteum (Figs. 265 and 266). If a mixed infection has not occurred, no fever or bad constitutional symptoms need be expected during this later stage. Sometimes the process is so acute as to cause actual sloughing or disintegration of the periosteum, so that the involucrum does not develop, and subsequent repair becomes difficult or impossible. Pathological fracture sometimes occurs as a complication if any strain is placed on a limb which has been weakened by osteo-myelitis.

When the medulla itself is more especially involved, the symptoms of pyæmia or of severe toxæmia become very prominent, and the child may die from this cause before the local mischief has been able to advance very considerably. The pain will continue to be of a severe character, although the patient's perceptions may be so blunted by the toxic condition that he becomes more or less unconscious. The swelling of the limb is not so great as in the former type, but the mischief may be very extensive, and although there is no great collection of pus beneath the periosteum, yet it may be stripped up along the whole length of the shaft, and even detached from the epiphysis at each end. Should the child not die of toxæmia, extensive destruction of bone is certain to result.

In infants and very young children, especially if the subjects of inherited syphilis, the disease early spreads through the epiphysis to the neighbouring joint, and the symptoms of acute suppurative arthritis supervene. The head of the humerus and the upper and lower ends of the femur are the parts most commonly involved in this way. In some of these cases the ligaments are so seriously weakened and relaxed that a loose flail-joint results, and pathological dislocation may result.

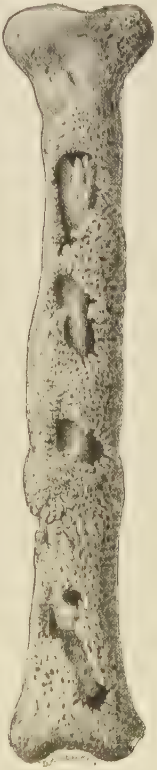

FIG. 266.—NECROSIS FOLLOWING ACUTE OSTEO-MYELITIS. (FROM SPECIMEN IN COLLEGE OF SURGEONS, MUSEUM.)

The irregular new bone of the involucrum is well seen, and within it portions of the sequestrum.

In the milder types of osteo-myelitis, the patients complain of severe pain in one of the bones (one type of 'growing pain'), and this may be attended by some degree of fever and of local disability. The symptoms may quiet down after a time and no harm result, but in some cases the growth of the bone will be checked or entirely stopped. In other patients a subacute or chronic abscess may form and perhaps come to the surface at a later date, and on opening it a sinus is found leading to the interior of the bone, in which a sequestrum of cancellous tissue is found. In such a case the surrounding bone may at first be rarefied to such an extent as to bend under the weight of the body, but in the later stages is certain to be much thickened and very sclerosed. The patient will have suffered from repeated attacks of pain in the bone, which may be felt to be thickened, and in the case of an encysted abscess a spot of localized tenderness can usually be detected.

The **Prognosis** of the acute form is always grave. Life may be threatened by pyæmia or toxæmia in the early stages, whilst later on hectic fever, amyloid disease, and exhaustion, may terminate the case if a mixed infection has occurred.

The utility of the limb may be unimpaired if the disease has not been too extensive, and if prompt treatment has been adopted; but if life is threatened by toxæmia, or if neighbouring joints suppurate, or if the osteogenetic powers of the periosteum have been destroyed by the acuteness of the process, amputation may be required. In cases which have recovered, excessive growth of the bones sometimes follows, owing to the long-standing hyperæmia of the part; but if the epiphyseal cartilage has been much affected, the limb may be stunted in its subsequent development.

Treatment.—Prompt surgical interference must be adopted in order, if possible, to cut short the malady. As soon as the local pain and high fever give evidence that this affection is present, a free incision should be made in the long axis of the limb through the periosteum, whether pus can be detected or not. The surgeon will then proceed to investigate carefully the condition of the bones by inspection and the use of the finger and probe. As a rule, he will find himself in the neighbourhood of the epiphyseal cartilage, and if the case has been taken in hand early, it is possible that the mischief will be quite limited; all that is then required is to scrape or gouge away the softened and hyperæmic bone at the end of the diaphysis, together with any necrotic tissue which may be present, taking the greatest care not to perforate the epiphyseal cartilage. The cavity thus formed is douched with an antiseptic; a drainage-tube or gauze packing is inserted, and in all probability recovery will rapidly ensue.

If the case has gone further, the periosteum will be found stripped from the bone for a varying distance, although but little pus may be present beneath it. Under these circumstances it is always necessary to open up by gouge, drill, or cutting-pliers the medullary canal, so as to allow pus to escape and the hyperæmic and gangrenous fatty tissue contained therein to be scraped out. If this proceeding involves a considerable portion of the shaft, it may be possible to leave bridges of compact tissue here and there, scraping out the medullary cavity beneath them. When grave constitutional phenomena are present, associated with loosening of the epiphysis, it will often be found expedient to amputate in order to prevent death from toxæmia.

If the periosteum has been extensively involved, a large amount of bone, possibly the whole diaphysis, is denuded, and perhaps both epiphyses are loosened. The dead diaphysis should be removed at once if the leg or fore-arm is involved, as there is always a second bone to maintain the length of the limb; but for the femur and humerus its removal should be delayed—immediate removal would lead to hopeless shortening and crippling of the limb.

When it is probable that the medulla is not much involved, the pus is given a free exit through an incision, the cavity is irrigated, and the stripped-up periosteum allowed to fall back upon the bone, and regain adhesions to it, if possible. Drainage is provided for, strict asepsis maintained, and the discharge soon becomes merely serous. A portion of the bone dies, and during its separation from neighbouring parts becomes encased in a newly-formed involucrum. When the sequestrum is free—that is, in about five or six weeks—*sequestrectomy* will be required; it consists in reflecting the periosteum from the new casing, and in enlarging or uniting one or more of the cloacæ, so as to allow the sequestrum to be withdrawn. In some cases it is desirable to approach the sequestral cavity by some safer route than that suggested by the sinus, *e.g.*, when the necrosis involves the lower end of the femur, it is often wise to cut down on it from the side, although the sinuses are central. It is not always easy to remove the sequestrum *en bloc*, and it may be necessary to divide it; the greatest care must be taken not to leave any portion behind, as the wound cannot heal in this case. The empty cavity should be irrigated and disinfected, and may be left to close by granulation, or be packed with gauze; sometimes it is possible to detach or fracture one side of the involucrum, and by pressing it down to obliterate the space partially and thereby hasten healing, which is often a somewhat slow process. Occasionally removal of the sequestrum is almost impracticable, and under such circumstances *amputation* may be preferable. This summary proceeding may also be needed in the course of this disease on account of pyæmia, defective repair, exhaustion from chronic toxæmia, or suppuration in a neighbouring joint.

Osteo-myelitis of the flat bones involves opening freely into the cancellous tissue by gouge or trephine, and scraping away all the bone which is diseased or infiltrated with pus. In the cranium the inner table should not be perforated unless the surgeon suspects the existence of subcranial suppuration.

3. The **Acute Traumatic Osteo-myelitis** which arises as a result of infection from without, *e.g.*, in cases of compound fractures, and after amputation, excision, or even osteotomy, requires a separate description. The clinical history of a case involving the shaft of a long bone is as follows: The patient during an attack of septic traumatic fever due to an injury or operation has one or more rigors, which suggest the existence of pyæmia, and is suddenly seized

with severe pain in the limb, which becomes intensely sensitive. On examining the wound, the soft parts are found to be unhealthy and infiltrated, the lower end of the bone is bare and yellow, and from the interior a stinking mass of gangrenous medullary tissue sometimes protrudes. Should early and efficient treatment not be undertaken, the patient runs a considerable risk of succumbing to acute pyæmia or toxæmia, whilst a varying amount of the interior of the bone dies (*central or tubular necrosis*), and a small segment of its whole thickness below, so that the sequestrum which ultimately separates is annular and conical (Fig. 267). Should the patient survive, the necrotic tissue gradually separates, and during this process a mass of new bone is formed from the under surface of the periosteum, so that the shaft becomes much thickened externally. In the slighter cases a mass of granulations projects from the medullary cavity of the divided end of the bone, and in this there may be a newly-formed bony substratum.

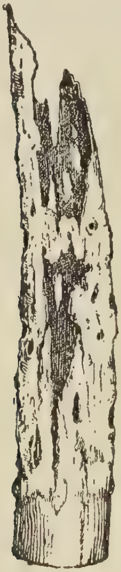

FIG. 267.—TUBULAR OR CONICAL SEQUESTRUM FROM ACUTE OSTEO-MYELITIS OF FEMUR AFTER AMPUTATION.

Treatment.—The wound is thoroughly opened up as early as possible, flushed out, and the sloughing medullary tissue scraped from the interior of the bone, which is subsequently disinfected with pure carbolic acid, a drainage-tube or gauze wick being placed in it for a few days. A certain amount of necrosis follows, but without high fever or toxæmia. Should this treatment fail, amputation will be required.

A similar process may also invade the *short bones*, and the cancellous extremities of long bones, being often secondary to acute infective arthritis, or to a compound fracture involving such parts. The local and general phenomena are very similar to those detailed above, except that no large sequestra are formed, the dead bone coming away in small spicules (one form of *caries necrotica*), whilst the pain and fever are less severe, and there is less likelihood of the development of pyæmia. *Treatment* consists in free drainage, removal of the infected tissue, and efficient purification of the wound.

TYPHOID OSTEITIS.

Affections of the osseous system are not uncommon in typhoid fever, and usually come on about the third week or during the early stages of convalescence. The tibia and ribs are most often affected, and in a large percentage of cases typhoid bacilli, with or without pyogenic cocci, will be found. It is curious to note how long the organisms may lie latent in the tissues before causing an abscess—in one case (Sultan's) for six years. The trouble commences either as a periostitis or osteo-myelitis, subacute in character, often improving for a time, and then relapsing. It usually develops an abscess, and then some amount of necrosis or caries may follow; thus in a case operated on by one of us a considerable sequestrum was removed from the upper third of the femur, whilst in the opposite leg there had been an abscess in a similar position, but without death of bone. The abscess is generally subacute or chronic, and the affected bone may be carious rather than necrotic. On its first appearance the affected limb should be elevated and fomented, and frequently the more acute symptoms will yield; but the part often remains enlarged, swollen, and tender, and exacerbations of pain are not unlikely to develop from time to time, sooner or later leading up to the formation of an abscess. When suppuration has occurred, the parts must be freely incised, diseased bone removed, granulation tissue scraped away, and the parts disinfected with liquefied carbolic acid. The wounds are usually found to be extremely chronic and indolent, and may require scraping several times.

CHRONIC INFLAMMATION OF BONE.

Chronic Osteo-periostitis is a chronic inflammatory condition of the bone, which results in overgrowth, thickening, and condensation.

Varieties.—(*a*) It may arise as a *localized* chronic periostitis, traumatic, toxic, rheumatic, or syphilitic in origin, or due to the close proximity of a chronic ulcer. It is characterized by a formation of new bone beneath the periosteum, the so-called *node* (Fig. 268), the cancelli of which are arranged at right angles to the surface. At first this new material is soft and spongy, but it rapidly becomes hard and sclerosed, and a similar condition affects the subjacent compact structure, which is thickened and indurated by a new formation around the Haversian canals. If the irritation persists, as in the case of a chronic ulcer, this condition may run on into the following variety.

(*b*) The *diffuse* form of chronic osteo-periostitis usually originates in some deep-seated or central affection, tuberculous or syphilitic in nature, and often involves the whole bone, although sometimes limited to one or other end. If tuberculous, there may be a small chronic abscess or some central necrosis, and around this the bone becomes thick and indurated. In the later stages a considerable new formation may occur beneath the periosteum, and the medullary canal become encroached on or obliterated

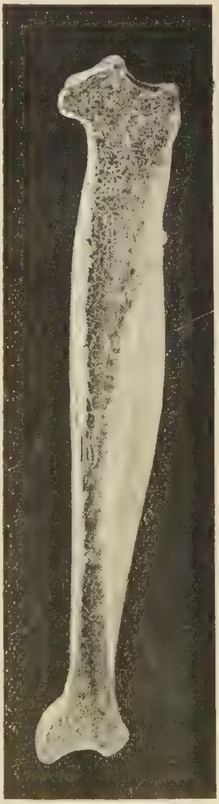

FIG. 268. — CHRONIC OSTEO-PERIOSTITIS OF TIBIA, SHOWING FUSIFORM SWELLING ON THE FRONT OF THE BONE, CONSISTING OF DENSE OSSEOUS TISSUE, AND THE MEDULLARY CAVITY ENCROACHED UPON. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

(Fig. 272). If syphilitic in origin, it may be due to a central gumma, or to a general condition of sclerosis, developing without any localized focus.

The **Symptoms** consist of deep aching pain in the limb, worse in bed, with perhaps tenderness over some particular spot, especially in cases where an encysted abscess exists in the head of a bone, such as the tibia. On examination the bone is felt to be thickened, and its surface more or less nodulated. If the disease is limited and superficial, a distinct node may be felt, consisting of a hard, fusiform, and tender swelling. Where the enlargement is more general, there is less tenderness, though the pain is constant.

The **Diagnosis** of such cases is not always easy, the enlargement of the bone being sometimes mistaken for the *early stage of a malignant tumour*. The rate of growth will be of little assistance, since it is very variable; but a tumour may have more defined limits, and its tension is often not the same throughout. Radiography is valuable in this direction, since in simple chronic periostitis the bone is solid and throws a continuous and well-defined shadow, while in malignant disease a certain amount of soft tissue is always present, either centrally or peripherally, easily penetrated by the rays, and hence leaving gaps in the shadow. If, in spite of such assistance, the case is still doubtful, an exploratory incision will be required.

The **Treatment** consists in resting the limb, applying counter-irritation (*e.g.*, iodine paint or the actual cautery), and giving iodide of potassium internally. If relief is not thereby obtained, it will be necessary to cut down over the whole length of the thickened bone through the periosteum, which is stripped aside, and if merely a nodular enlargement is present, to chisel away the new formation. When the whole thickness of the bone is involved, a gutter or trench must be made by gouge and mallet, extending into the medullary cavity, and its length corresponding to the enlargement. The soft parts are loosely drawn together; the hollow will fill with blood-clot, which is allowed to organize. If enough bone has been removed, most satisfactory results follow; but in some aggravated conditions which have lasted for many years amputation is required.

Tuberculous Diseases of Bone.

Bone may be affected in many ways by tubercle, the process starting either beneath the periosteum or more commonly in the cancellous tissue of the interior. The infection is obviously secondary to disease elsewhere, and the bronchial or mesenteric glands are the commonest source of its origin. The osseous affection is often insidious in its onset, and chronic in its course; it has a considerable tendency to involve neighbouring joints and to give rise to suppuration.

1. In **Tuberculous Periostitis** a specific infiltration of the periosteum is met with, consisting of a deposit, partly in that membrane

and partly under it, of pulpy granulation tissue containing the characteristic miliary tubercles, which are chiefly developed around the vessels passing from the periosteum into the bone. As in tuberculous disease elsewhere, caseation and suppuration are likely to follow, leading to the formation of abscesses, which are primarily subperiosteal and filled with curdy pus; these in time find their way to the surface, either directly or by more or less tortuous channels, and leave sinuses, extending down to the diseased area. The effect on the bone may be insignificant if the part affected is dense, consisting merely in some slight superficial erosion; occasionally, however, the disease may spread along the periosteum, and involve a neighbouring epiphysis or joint. If the compact layer is *thin*, as in the sternum, ribs, or bodies of the vertebræ, the underlying cancellous tissue is almost certain to be secondarily affected, and caries will result.

Clinical History.—In a superficial bone a doughy or pulpy swelling forms, which is slightly tender on pressure. It takes weeks or months to develop, and on radiography the underlying osseous tissue may appear quite normal in texture. In the later stages, when caseation or suppuration is present, the swelling often becomes more defined and somewhat resembles an ordinary node, but is more irregular in shape, of somewhat unequal consistency, and on firm pressure small portions may be felt to give way. If an abscess forms, the skin becomes reddened, the swelling is elastic to the touch, and the pain greater, but it diminishes as soon as tension is relieved by discharge of the pus. A sinus, however, forms, and a probe passed down impinges on soft carious bone. The admission of pyogenic infection increases the trouble.

Treatment.—In the early stages, constitutional treatment may suffice, together with rest and carefully-adjusted pressure, as by strapping with Scott's dressing, or Bier's induced hyperæmia, where applicable. The condition, however, demands incision if a neighbouring joint is threatened, or when suppuration has occurred. Free removal of all the granulation tissue and softened bone with a Volkmann's spoon is required, disinfection of the cavity with undiluted carbolic acid, and packing it with gauze soaked in a sterilized emulsion of glycerine and iodoform (10 per cent.), the wound being allowed to granulate from the bottom. If a rib is involved, it is wiser to remove entirely the affected portion of bone.

2. **Tuberculous Osteitis** arises in cancellous tissue, and usually in the epiphyses, or under the articular cartilage; occasionally it develops in the medullary cavity as a chronic osteo-myelitis.

Pathology.—The tubercle bacilli are deposited in the interior of the bone, which may have previously sustained some mild injury. The outcome of this is the transformation of the normal medulla into pulpy granulation tissue containing tubercles, the bony cancelli becoming meanwhile eroded and rarefied, and the bone corpuscles undergoing fatty degeneration (*vide* Caries, p. 557). Sequestra occasionally form, but more often in adults than in children, owing to the greater density of the bone in the former. They are due to a cutting-off of the blood-supply of a definite portion of the bony tissue, either as a result of tuberculous endarteritis, or from early caseation within the cancelli of the whole of the granulation tissue. The sequestra are soft and friable, usually yellowish-white in colour from the presence of the caseating tissue in their substance, and are seldom completely separated from the surrounding bone. When the tuberculous disease does not involve the whole bone, the nearest healthy tissue may become sclerosed, and thus one not unfrequently finds a central sequestrum surrounded by rarefied bone, which in turn is enclosed by a zone of sclerosed tissue. Very frequently the disease extends from the interior of the bone either to a neighbouring joint or to the periosteum, or possibly to adjacent tendon sheaths, and external abscesses are then likely to develop. The admission of pyococci leads to increasing rapidity of the destructive process, and minute spiculated sequestra often come away in the discharge. Radiography is a useful adjunct in estimating the amount of disease present, since the affected bone offers little or no resistance to the passage of X rays (Fig. 269).

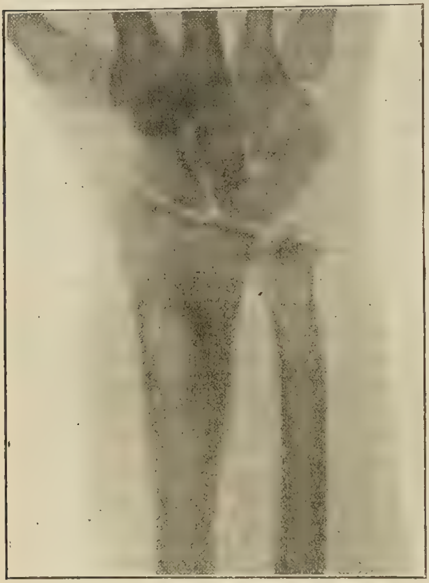

FIG. 269.—TUBERCULOUS DISEASE OF RADIUS.

The patient was a lady over fifty years of age, who had suffered for some months from pain and swelling of this bone. The site and extent of the disease is indicated by the light area in the shadow of the bone. Eventually amputation was required.

(*a*) The *short bones of the hands and feet* are very liable to this condition in weakly children whose general health has been depressed by one of the exanthemata. Some slight injury may determine the onset of the attack, which frequently involves several bones simultaneously. When the phalanges are involved, the disease is known as **Tuberculous Dactylitis.**

Clinical History.—The affected segment of the finger becomes slowly enlarged, bulbous, and painful, the pain being, however, slight in amount, though sometimes worse at night. At first the finger looks white, and the skin is smooth and shiny; but after a time one spot rapidly increases in size, becoming red and tender, and finally an abscess forms, which bursts or is opened, leaving a sinus, down which a probe can be passed into the carious interior of the bone. Occasionally contiguous joints are involved in this process, whilst the tendon sheaths are also liable to be affected; a large portion of the swelling is often due to periosteal infiltration (Fig. 270). In some cases the bone appears to be expanded, but the term *expansion* is scarcely correct, inasmuch as the enlargement is due to absorption on the inner aspect, whilst there is a new formation of bone under the periosteum. Natural cure without suppuration is known to occur, but even then the growth of the phalanx may be hindered, and the finger remains shortened.

The **Treatment** of tuberculous dactylitis in the early stages consists in attention to the general health, together with local rest, induced hyperæmia, and perhaps strapping the part with Scott's dressing. Should the disease progress or suppuration occur, operation must not be unduly delayed, since neighbouring joints and tendon sheaths are likely to be attacked. An incision is made down to the bone at some suitable spot where tendons or other important structures will not be injured; the periosteum is divided, and the outer layer of compact bone removed by gouge, so as to allow the diseased medulla to be scraped away with a Volkmann's spoon. The cavity is swabbed out with liquefied carbolic acid, any excess being washed away with absolute alcohol, and the wound packed with gauze soaked in iodoform emulsion, in order to ensure healing by granulation. In this operation the integrity of epiphyses and of articular cartilages must be carefully respected. Not unfrequently the growth of the bone is considerably hindered, either by the disease or by the treatment requisite in order to eradicate it, the part becoming stunted or deformed in consequence. In the worst cases amputation is required.

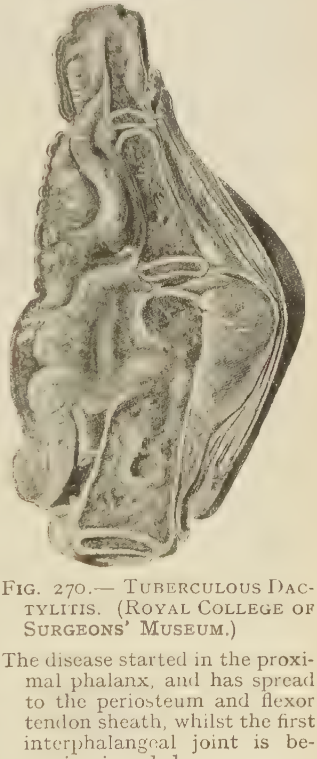

FIG. 270.— TUBERCULOUS DACTYLITIS. (ROYAL COLLEGE OF SURGEONS' MUSEUM.)

The disease started in the proximal phalanx, and has spread to the periosteum and flexor tendon sheath, whilst the first interphalangeal joint is becoming invaded.

(*b*) Any of the *bones of the tarsus* may be involved in exactly the same manner, the clinical history and treatment being identical, although articular lesions are more common than when the disease is limited to the phalanges. The affected portion of the foot becomes swollen and shiny, since the overlying periosteum is often involved in the process; and it is sometimes difficult to determine whether the lesion is limited to the bones or also involves the joints. In the early stages one part of the foot may be more swollen than another, according to the location of the trouble. The os calcis is most often affected, and afterwards, in order of frequency, come the first metatarsal, astragalus (the head), and scaphoid. When it starts in the astragalus, the swelling occurs below the level of the ankle-joint in front of or behind the malleoli, whilst pressure over the head of the bone gives rise to pain. The foot is usually in a position of equinus, but not to such a marked degree as when the ankle-joint itself is affected; the subastragaloid movements (inversion and eversion, abduction and adduction) are also considerably limited, or may be absent. An examination of the accompanying illustration (Fig. 271) will explain the fact that tuberculous disease starting in the astragalus is very likely to involve the ankle-joint, or to spread to the os calcis or scaphoid. Disease of the os calcis leads to more limited swelling of the back of the foot on one or both sides of the heel; the movements of the ankle will not be impaired, although walking is painful, and hence the patient limps, treading only on the toes. Further forwards, tuberculous disease is most likely to start in or around the scaphoid, the bulbous swelling of the foot being then shifted anteriorly, and the movements of the ankle remaining unimpaired. Owing to the arrangement of the synovial membranes, the prognosis is much worse when the disease attacks the inner half of the foot, comprising the astragalus, scaphoid, cuneiform, and three inner metatarsal bones, than when it

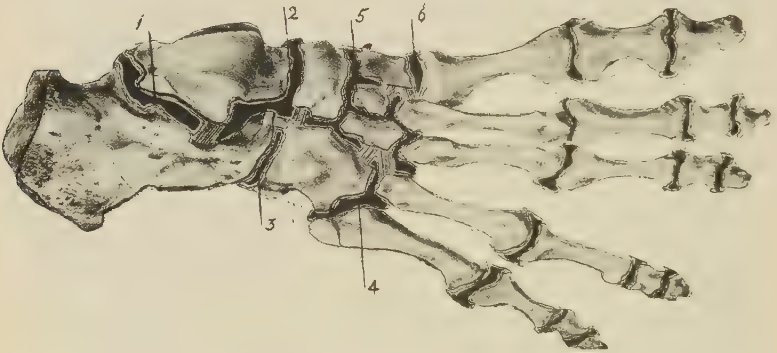

FIG. 271.—ARRANGEMENT OF SYNOVIAL MEMBRANES OF FOOT.

1, Posterior calcaneo-astragaloid, behind the interosseous ligament; 2, anterior calcaneo-astragaloid and astragalo-scaphoid; 3, calcaneo-cuboid; 4, cubo-metatarsal; 5, the large common sac between scaphoid and cuneiform, between the three cuneiform bones, and between the cuneiform and second and third metatarsals; 6, between the internal cuneiform and first metatarsal.

affects the outer segment, consisting of the cuboid and two outer metatarsals, which are excluded from the general synovial membrane, and are thus more amenable to treatment.

Sooner or later suppuration occurs, with increased pain, and, should the sinus which results from opening the abscess become septic, the trouble is sure to spread much more rapidly, and the prognosis becomes increasingly grave.

The **Treatment** consists in the usual local and constitutional measures adopted in tuberculous disease (p. 184). In the early stages the foot and ankle are immobilized, and preferably in plaster of Paris or water-glass, and the foot is not allowed to be used until all pain has ceased. Older patients are fitted with a Thomas's knee-splint and a patten, and allowed to get about on crutches.

Should the disease persist, or should suppuration occur, operation will be required. If the *os calcis* alone is involved, it will usually suffice to open it from one or both sides, to scrape out and disinfect its interior, and then pack it with iodoform and gauze. The cavity fills with granulation tissue, and subsequently with fibrous tissue, with perhaps a few bony spicules, and a marked permanent depression always remains at the site of operation. If the disease mainly affects the *astragalus*, it may suffice to remove it entirely, neighbouring articulations being curetted; but probably the disease will have spread so far that amputation will be required, and then Syme's operation is better than methods, such as Pirogoff's, which retain any portion of the tarsus. Disease of the *cuboid* and outer half of the foot in front of the os calcis can often be dealt with efficiently by scraping, but when the common synovial membrane on the *inner side* is involved, amputation will probably be needed.

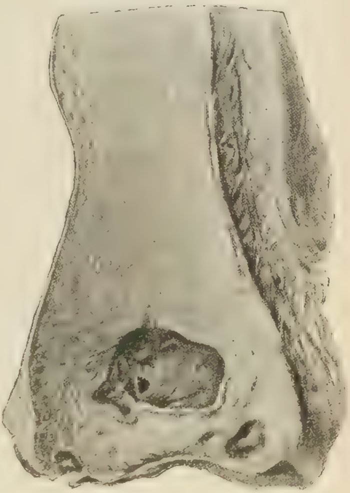
FIG. 272.—CHRONIC ABSCESS IN THE LOWER END OF THE TIBIA. (KING'S COLLEGE HOSPITAL MUSEUM.)

(*c*) If the tuberculous disease affects *the ends of long bones*, it most commonly starts in the epiphysis, or under the articular cartilage, though sometimes on the shaft side of the epiphyseal cartilage. The changes already described take place, and lead to early destruction of the latter cartilage, so that the adjacent parts of both epiphysis and diaphysis become involved (**tuberculous epiphysitis**). The general signs are similar to those present when the smaller bones are affected, but the results produced may vary considerably. (i.) In the earlier cases where efficient treatment is adopted, the tuberculous tissue may be totally absorbed, and the process thus comes to an end, though the affection of the epiphyseal cartilage may lead to subsequent impairment of growth. (ii.) In others it may be circumscribed by the bone becoming sclerosed around a caseating focus, and then, if suppuration ensues, a *deep abscess in the end of the bone* may be produced (Fig. 272). Such is rarely of large size, containing at most 1 or 2 drachms of curdy pus, and is lined by a definite pyogenic membrane of the usual tuberculous type. The effects produced by this condition are similar to those of any chronic inflammation of bone, viz., a deep aching or boring pain, worse at night, together with enlargement of the affected bone, whilst one spot is often very tender on palpation. If it has existed for any length of time, the whole shaft may become enlarged as a result of chronic osteo-periostitis. (iii.) The disease may burrow along the epiphyseal line, and find its way into the neighbouring joint, if the epiphysis is intra-articular, as in the hip; but if the epiphyseal cartilage is placed beyond the limits of the capsule, a subperiosteal extra-articular abscess will develop (Fig. 273). Should the disease spread equally in all directions, the epiphysis may actually be separated. (iv.) A more common result is for the

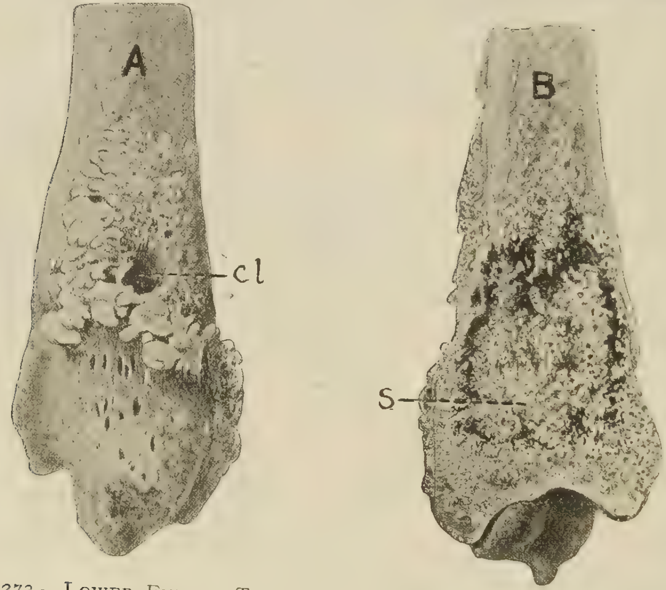

FIG. 273.—LOWER END OF TIBIA AFFECTED WITH TUBERCULOUS DISEASE. (KING'S COLLEGE HOSPITAL MUSEUM.)

In A, a subperiosteal deposit of new bone is seen surrounding an opening (cl), which leads into the interior of the bone; in B, the interior of the same bone is seen, and shows a sequestrum (S) just above the epiphyseal line. The ankle-joint is healthy.

whole or part of the cancellous tissue of the epiphysis to become involved, and the joint to be secondarily affected with tuberculous arthritis, either by perforation, erosion, or necrosis of the articular cartilage, or by extension to the synovial membrane around its margins. (v.) The process may sometimes extend upwards along the medulla into the shaft, causing a diffuse osteo-periostitis, with or without a medullary abscess (Fig. 274).

The **Treatment** of tuberculous epiphysitis is conducted in the first place by absolute immobilization and hygienic measures; but the surgeon must not be tempted to trust too long to such a régime, for fear of the joint becoming also affected. If considered necessary, an opening is made into the interior of the epiphysis, and all the pulpy granulation tissue, caseous débris, or diseased bone removed with a sharp spoon, the cavity being subsequently disinfected, and packed with gauze infiltrated with iodoform. Of course, the utmost care must be taken not to open the joint by scraping through the articular cartilage. Where a chronic abscess exists in the end of a bone, a trephine should be applied over the tender spot, and, if the cavity is not at first opened, the bone may be drilled in different directions to ascertain whether or not pus exists.

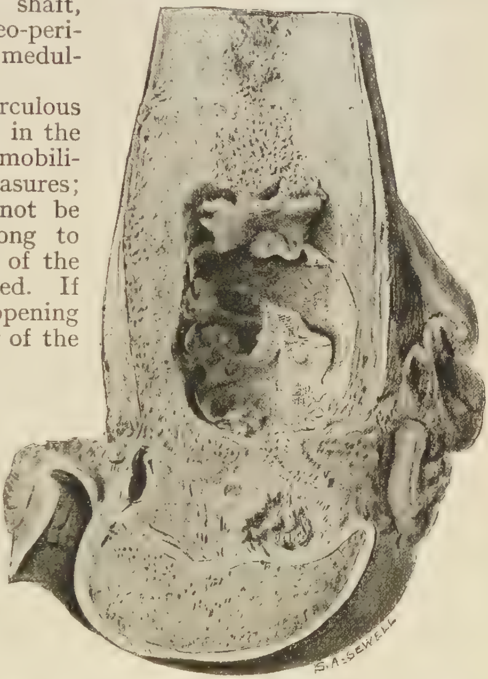

FIG. 274.—LOCALIZED ABSCESS IN THE LOWER END OF THE FEMUR, EXTENDING FROM THE EPIPHYSEAL LINE UPWARDS INTO THE MEDULLA. (FROM SPECIMEN IN THE COLLEGE OF SURGEONS' MUSEUM.)

(*d*) The *medullary canal* of the shaft of a long bone sometimes becomes the seat of tuberculous disease; this, as also the abscess of bone described above, is more common in adults than in children. The part thus affected becomes carious, with or without the formation of sequestra or pus; but the most marked feature of this deep-seated central trouble is that the whole bone passes into a state of chronic inflammation, which we have described, as well as the treatment necessary for it, under the title of chronic diffuse osteo periostitis (p. 569).

Syphilitic Diseases of Bone.

In the **Secondary Stage** flying pains about the bones (sometimes termed *osteocopic*) are often complained of; they are, however, of but little importance, and disappear rapidly as the patient gets under the influence of mercury. In the late secondary or early tertiary periods, a *periosteal node* is often met with, as a result of chronic periostitis. It usually affects only one bone, and most commonly the tibia, and consists of an infiltration and thickening of the periosteum, which may entirely disappear, but later on is accompanied by a formation of new bone. This is at first spongy and soft in character, but after a while becomes hard and sclerosed. When such has once occurred, absorption of the newly-formed bone does not readily follow, even under treatment, the part perhaps remaining permanently thickened. It is recognised clinically as a fusiform swelling, a little tender on pressure, and the seat of deep aching pain, usually worse at night. It must be understood that the pain is not so much associated with the onset of night as with the increased warmth of the limbs when in bed; indeed, patients with syphilitic tibiæ frequently sleep with their legs exposed. Night-watchmen and others, on the contrary, complain of pain during the day, when they take their rest. Suppuration does not often occur, and constitutional rather than local treatment is required.

In the **Tertiary Period** the bones may participate in the changes which involve any and every tissue of the body. The following lesions are described:

(*a*) The formation of *subperiosteal gummata*, either localized or diffuse, probably resulting in *caries* of the subjacent bone; if the affection is limited, only a small portion may be thus involved; but where it is widely diffused, an extensive surface of the bone may become eroded and irregular. This process is sometimes accompanied by a development of new bone under the adjacent periosteum, and is very often complicated by sclerosis and necrosis. The calvarium is the part most frequently involved, and as but little new bone forms in this situation the skull often presents a curiously pitted or worm-eaten appearance (Fig. 275). Frequently the overlying scalp is invaded and destroyed by the gummatous process, permitting the entrance of pyogenic organisms, and giving rise to deep and sometimes extensive wounds, discharging an abundance of foul pus, at the bottom of which bare and even dead bone may be felt.

(*b*) At the same time a condition of *sclerosis* may be produced in the underlying or surrounding parts, and this may progress to such a degree as seriously to compress and constrict the vessels in the Haversian canals. Moreover, an obliterative endarteritis is almost always present, and these factors, combined with the separation of the periosteum by the above-mentioned gummatous changes, so interfere with the vitality of the bone that, should pyococci be admitted, necrosis is almost certain to ensue.

The effects produced vary considerably in different cases, and especially with the situation. When the *calvarium* is attacked, pyogenic infection often supervenes, owing to the thinness of the scalp and the depth to which the hair follicles penetrate, and consequently necrosis is common. The process in such a case, as is represented in Fig. 276, is probably as follows: The pericranium corresponding to the necrotic area becomes gummatous, and at the same time the subjacent bone undergoes sclerosis. Sooner or later the gummata burst or are opened; pyogenic infection occurs, and the scalp tissues are stripped off the calvarium to the limits of the disease, necrosis resulting in the sclerosed area of bone. A line of rarefaction subsequently forms around the sequestrum in consequence of Nature's attempts to separate it. The later stages of the disease are marked by extreme chronicity, the sequestrum lying bare in the wound perhaps for years without being separated, owing to the slight degree of vascularity and the extreme condensation of the surrounding parts. Moreover, as explained above, there is an entire absence of an involucrum. In the *shafts of long bones*, where the compact tissue is thick and resistant, there may be extensive periosteal disease, with but little affection of the underlying parts; but if this compact layer is thin, and especially when the cancellous ends are involved, a considerable amount of destruction from caries may result, though if pyococci are not admitted there will be an entire absence of necrosis.

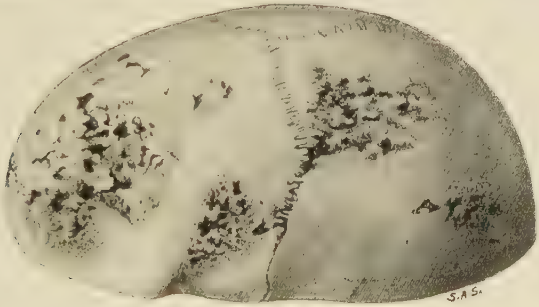

FIG. 275.—SYPHILITIC CARIES OF SKULL FROM DIFFUSE GUMMATOUS DISEASE. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

The *sternum* is not uncommonly affected by syphilitic disease, which manifests itself as a gumma, which breaks down and suppurates, but does not often cause much bone destruction. The *nasal bones* and *hard palate* are frequently the site of subperiosteal gummatous formation, resulting in suppuration and necrosis: a foul discharge from the nose results in the former case, which may be followed by destruction of the septum nasi and permanent deformity. The palatal trouble often results in perforation.

In the **Treatment** constitutional remedies must be employed, and will be valuable if suppuration and necrosis have not occurred. They may have but little effect, however, if pyogenic infection has supervened apart from measures directed to providing effective drainage and removal of the dead bone. In the calvarium, however, no attempt should be made to take away the dead bone unless it is loose.

(*c*) Occasionally a *gummatous osteo-myelitis* is met with, in which a gumma forms in the interior of a bone. It results in the so-called expansion of bone and secondary thickening and enlargement of its whole structure—*i.e.*, a diffuse chronic osteo-periostitis. The symptoms are the same as those described for the latter affection, and if it resists the administration of anti-syphilitic remedies, it must be treated in the same way, viz., by separation of the periosteum, freely opening the medullary cavity, and removing all diseased tissue. These cases when affecting the long bones have often been mistaken for malignant growths; necessarily, it is a matter of the greatest importance to come to a right conclusion as to their nature. The greater rapidity of growth in the syphilitic cases, and the evidences of tertiary lesions elsewhere, or of a syphilitic history, and the existence of a positive Wassermann reaction, will often guide the surgeon to a right conclusion, whilst radiography is also helpful; but if there is any doubt an exploratory incision and a microscopic examination of the diseased tissues should always be made before amputation is undertaken.

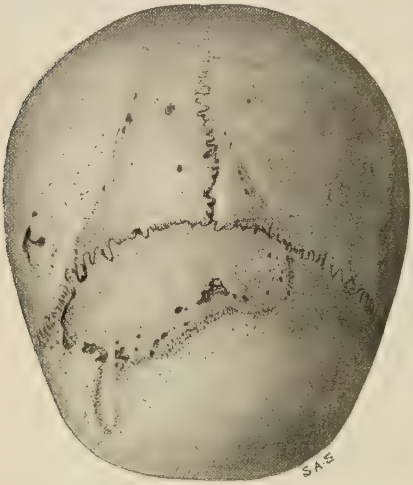

FIG. 276.—SYPHILITIC NECROSIS OF THE SKULL (KING'S COLLEGE HOSPITAL MUSEUM.)

The sequestrum is becoming separated, and a ring of caries is forming around it.

In **Inherited Syphilis** any of the above manifestations may be seen, but with more or less special features added, and, in addition to these, certain forms which do not occur in the acquired type of the disease have been described.

1. A new formation of bone beneath the periosteum is perhaps the most frequent result, and this occurs with but little pain. Perhaps the most common situation of this lesion in infants is the calvarium, where bony masses known as *Parrot's nodes* form around the anterior fontanelle, causing the top of the skull to resemble a 'hot cross bun' in shape. In the early stages the bone is soft and spongy, and on post-mortem examination is dark red or maroon in

colour. If the process is not checked by suitable antisyphilitic treatment, the newly-formed osseous tissue becomes dense and sclerosed, and the deformity may then persist through life (Fig. 39, p. 173). Any part of the calvarium may, however, be affected, and the change is not necessarily limited to the first years of life.

2. A somewhat similar condition is met with in the shafts of long bones, due to the deposition of alternating lamellæ of soft and hard bone outside the ordinary compact tissue and beneath the periosteum.

3. *Syphilitic epiphysitis* (or, as it is termed, syphilitic *osteo-chondritis*) is a lesion characterized by enlargement of the ends of the bones, as in rickets, but coming on within the first year after birth. The enlargement is mainly situated in the epiphysis, but also extends some way along the shaft, thus contrasting forcibly with rickets. Occasionally only one side of the epiphysis is affected. The change commences in the zone of calcified cartilage nearest the diaphysis, which becomes friable, opaque, and irregular, and as the condition progresses it may be transformed into granulation tissue, so that separation of the epiphysis follows. Pyogenic infection may follow, resulting in suppuration and necrosis of the epiphysis or acute arthritis, or the limb hangs powerless in a condition known as *syphilitic pseudo-paralysis.* The disease is usually symmetrical, and often multiple, and situated in much the same positions as rachitic affections, the knees, elbows, and wrists being perhaps most often affected. It may terminate in the early stages, and be followed by organization of the granulation tissue, the ultimate result being cessation of growth in the bone.

4. A symmetrical overgrowth of the tibia, perhaps combined with an anterior curvature, also occurs in syphilitic children, resulting in permanent elongation of the legs (p. 457).

5. *Craniotabes* consists of a localized absorption of the osseous tissue of the cranium, leaving small areas where the bone is thinned or absent, so that on pressure a sensation of crackling, like that of parchment, is imparted to the finger. It occurs most frequently in the parietal bone (in 60 per cent. alone; in 95 per cent. with other bones—Carpenter*), and in the majority of cases within the first six months of life, a fact that throws considerable doubt on the idea that it is due to rickets.

The **Treatment** of syphilitic lesions in children must be carried out in accordance with general principles, and mainly by the administration of suitable drugs.

Rickets.

Rickets is a general disease of malnutrition, occurring in children and manifesting itself mainly in lesions connected with the bones. It usually commences within the first three years of life, but sometimes appears later.

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* Carpenter, 'Syphilis of Children in Every-day Practice.' **Baillière, Tindall and Cox.** 1901.

Causes.—Rickets is induced chiefly by giving to the child insufficient or improper food, especially by the too early administration of starchy materials and the want of suitable fats, whilst uncleanliness and want of air and light also predispose to it. Prolonged lactation is not necessarily a cause, if the mother is healthy and capable of feeding the child; but amongst poor patients this habit is frequently responsible for its appearance, although in Japan, where the children are suckled for two or three years, the disease is unknown. Syphilis has no causative connection with rickets, except by inducing marasmus and digestive and assimilative disorders.

The **Symptoms** may be divided into the early or general, and the later or osseous. The *general* symptoms are mainly referable to a state of irritability of the gastro-intestinal mucous membrane. The child may be fat and flabby, or thin and emaciated; the mucous membranes are pale, and vomiting and diarrhœa are constantly present, the motions being often green, slimy, and very offensive. The spleen is enlarged, the abdomen tumid, and profuse sweating of the head is very characteristic.

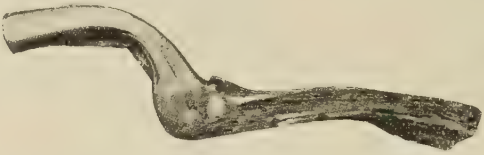

Fig. 277.—Section of Costal Cartilage and of End of Rib in Rickets, showing Depression at the Junction on Anterior Surface and Projection on Inner Surface.

The commencement of the *osseous changes* is usually indicated by increasing irritability and restlessness, the child tossing off his bedclothes at night, and crying out when handled or touched. The articular ends of the long bones become enlarged, as also the junction of the costal cartilages with the ribs. Sooner or later the shafts of the long bones soften, and may bend in various directions, and thus many *deformities* may be produced.

The *head* usually becomes flattened antero-posteriorly, so that the forehead appears square in shape and enlarged, whilst frontal bosses may develop on either side, due to new formation of bone under the periosteum; it is a question, however, whether these are not syphilitic rather than rachitic in origin. The fontanelles remain open much longer than usual, and craniotabes is said to occur. The teeth do not erupt till late, and are stunted, defective in enamel, and easily eroded, so that the ends of the incisors are often concave; they must not be mistaken for syphilitic teeth, since the concavity is a small arc of a large circle, whilst the typical notch of syphilis is a large segment of a small circle.

The *spine* may be affected by kyphosis (p. 440), or less frequently by scoliosis (p. 435); the kyphotic curve results when the patient is allowed to lie too much in bed with the head on a high pillow, or if the child is carried about with a curved back; scoliosis more often occurs when the patient is able to walk. Occasionally a kypho-scoliosis is produced as a result of the child being carried about sitting on a nurse's arm with the pelvis tilted.

Changes in the *thorax* are produced by enlargement of the costo-chondral junctions (*beaded ribs*), which, when present on either side of the sternum, produce what is known as the *rickety rosary*. The swelling is more marked on the pleural aspect than on the outer side of the bone (Fig. 277). If there is any obstruction to the entrance of air into the lungs, as from tracheitis or bronchitis, the atmospheric pressure may cause the softened bone and cartilage to sink inwards, and as a result of this the sternum may be pushed forwards (*pigeon*

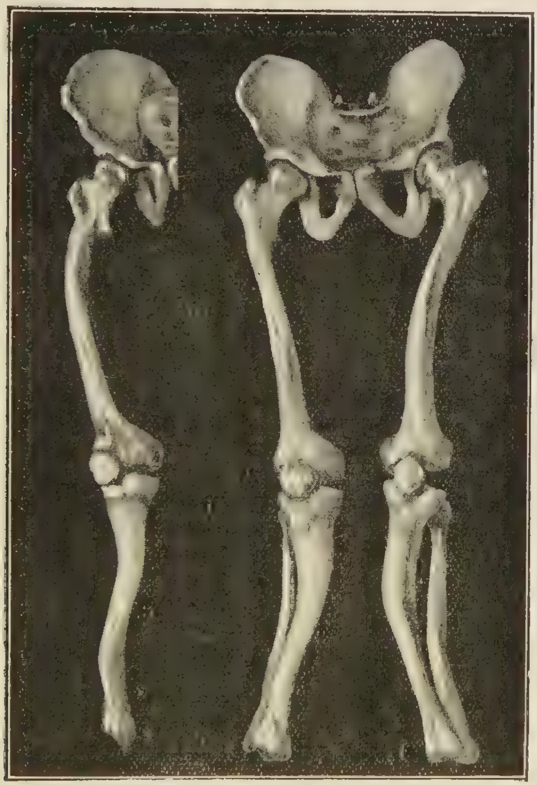

FIG. 278.—PELVIS AND LEG-BONES IN RICKETS. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The photograph on the left is taken from the side, in order to show the extent of the antero-posterior curvature of the bones.

breast), whilst the curvature of the ribs at the angle is increased. A very characteristic feature of the rickety change consists in the lateral groove thus produced on each side of the sternum, which may meet with a transverse depression below, caused by the projection of the lower floating ribs by the tumid abdomen.

The *pelvis* is flattened antero-posteriorly, or more rarely triradiate, the former condition being produced when the patient lies habitually on his back, the latter only occurring when walking is permitted, the acetabula being then pressed inwards and backwards by the heads of the femora.

The deformity of the *long bones* (Fig. 278) usually consists in an increase in their natural curves, especially at points where powerful muscles are attached. The femora are curved antero-posteriorly, and the tibiæ in a similar direction, although there is often some lateral displacement superadded. Most commonly the lower end of the tibia is bent inwards—*i.e.*, in a direction opposite to that represented in Fig. 278. Genu valgum or varum may also result from these changes (pp. 452, 455, and 456).

When the acute stage of rickets has passed away, any deformities present become fixed by the complete ossification of the softened bony tissues. As a rule the density of such deformed bones is increased, whilst their natural shape is altered by deposits of new subperiosteal bone or struts in the concavities, so that on section they are usually more or less flattened from side to side, and the medullary canal appears to be displaced towards the convexity. Growth is often checked by this disease, and thus the individual becomes stunted and dwarf-like.

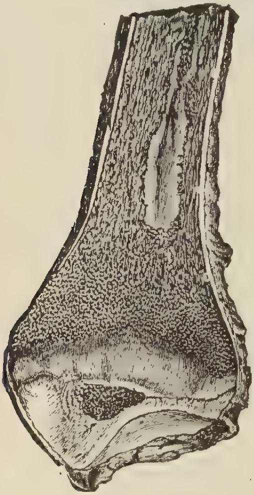

FIG. 279.—SECTION THROUGH LOWER END OF RICKETY RADIUS, SHOWING EXAGGERATED DEPTH AND IRREGULAR BORDERS OF THE PROLIFERATING EPIPHYSEAL CARTILAGE.

(From Ashby and Wright's 'Diseases of Children.')

Pathologically, the chief changes in rickets are found in the neighbourhood of the epiphyses. Ordinarily, the epiphyseal cartilage is a lamella about a line in thickness, bounded on either side by a zone of calcified tissue, containing regular alveolar spaces filled with vascular medulla, and lined by osteoblasts, passing gradually into normal cancellous bone. In rickets the epiphyseal cartilage is not only circumferentially enlarged, but also thickened and irregular (Fig. 279), outgrowths of cartilage projecting on either side into the calcified tissue, which is more abundant and more open in texture than usual, whilst it passes irregularly into the cancellous bone. Thus, there is an increased preparation for the formation of bone, but the ossifying process is inefficiently carried out. In addition to this, the Haversian canal systems and the medullary spaces in the diaphyses are enlarged, so that the bones become weaker and less rigid from the insufficient amount of lime salts present, and thus readily bend under the weight of the body or from muscular action. Less frequently the subperiosteal compact bone becomes similarly rarefied. When the disease comes to an end, the deformities may persist, but the bone, now effectively ossified, becomes harder and stronger than usual.

In the **Treatment** of rickets the most essential feature in the early stages is the correction of all errors in the personal hygiene. The diet should consist of good cow's milk, diluted if need be, and with lime-water added; whilst the juice expressed from raw beef, or one of the many meat juices now sold, may also be administered. The condition of the bowels must be attended to, and the child placed in as good surroundings as possible. Cod-liver oil must be administered, together with Parrish's food (syr. ferri phos. co.). Deformities must, if possible, be prevented by keeping the child in the recumbent posture and not allowing it to crawl or run about. The early stages of deformity in young children can often be corrected by daily manipulation of the affected bones; for the legs, it may suffice to keep them off their feet, as by a splint which extends from the thighs 6 inches below the soles; a certain amount of pressure can also be exercised by this appliance. Osteotomy, or even resection of portions of bone, is required in the severer cases where the deformity persists, and the bony changes have become consolidated (see p. 457).

Adolescent Rickets comes on about puberty, and is usually independent of an early rachitic history, although in a few cases it may be looked on as a recrudescence of the infantile ailment. Imperfect nutrition is probably a less important ætiological factor than in infancy; but strain, mental or physical, combined with defective hygiene, has been present in most instances. The chief changes are to be found in the shafts of the long bones of the legs, which become bent from the superjacent weight of the body. Deformities in the upper extremities are less frequent. Enlargement of the epiphyses is also observed. There is usually no sweating of the head, but the patient is pale, and complains of fatigue and languor, but not of pain. The softened bones bend, and no buttresses or struts are formed in the concavities; hence the deformities produced are often serious, and the course of the case is slow. (See Fig. 170, which occurred in a girl of thirteen years, the subject of this affection.) *Treatment* must be directed towards an improvement of the general health and of the conditions of life; undue mechanical strain must be avoided, and, if need be, the patient kept at rest. Deformities are dealt with by the use of orthopædic appliances or by osteotomy.

Infantile Scurvy (*syn.:* **Barlow's Disease, Scurvy Rickets, Hæmorrhagic Rickets**).—This condition, first accurately described by Sir Thomas Barlow, presents the symptoms of scurvy in a rachitic child, and in its manifestations either one or the other set of phenomena may predominate. It is usually seen in the children of well-to-do people from four to eighteen months old, and apparently arises from defective nutrition, especially from the prolonged administration of peptonized or prepared foods, or even possibly of sterilized milk. In the slighter cases there may be but little evidence of the scorbutic condition, beyond the fact that in a rickety child there is some tendency for the gums to bleed, or a little hæmaturia; but in those that are more marked the rickety signs are of little importance compared with those due to hæmorrhagic extravasations. The disease often comes on suddenly with some amount of pyrexia, rarely exceeding 102° F., but the child is evidently ill, and perhaps complains of tenderness of the limbs, which may be kept so quiet as to suggest that they are paralyzed. This is followed by the appearance of swellings of some size, due to sub-periosteal extravasations, the skin over the affected parts being at first shiny and œdematous, but subsequently becoming stained by the blood-pigment. The femur and tibia are most often affected in this way, and the epiphyses may occasionally become detached, or even spontaneous fractures occur. Bleeding may also take place beneath the conjunctiva or in the orbit, leading to protrusion of the eyeball, whilst there may be blood-stained diarrhœa, hæmaturia, or epistaxis.

The disease, when recognised, is readily amenable to *treatment*, but should its nature be overlooked, the child is likely to become emaciated and die. Attention to the diet is the main point to be attended to, for when fresh milk, lime-juice, or vegetables are given, the symptoms soon disappear. The affected limbs must be kept at rest, and cooling lotions applied, whilst splints are required when epiphyses are separated or fractures have occurred.

Achondroplasia (**Chondrodystrophia fœtalis**) is a curious congenital condition, somewhat resembling rickets, in which the growth of osseous tissue on the shaft side of the epiphyses of the long bones of both arms and legs is defective, so that the limbs are short and stunted, and the stature correspondingly diminished, although the epiphyses are normal. The bones generally are not bent or curved abnormally, though there is probably some change of the neck or shaft of the femur, resulting in lordosis, which is very marked when the patient stands. The fingers taper to their tips, and are separated one from another in ' spoke-like ' fashion. The bones at the base of the skull, being of cartilaginous origin, undergo premature synostosis, whilst the upper half of the skull, being derived from membrane, and therefore developing naturally, looks unusually large; the face is small, and the bridge of the nose depressed as in congenital syphilis. The children, if they live, are usually efficient in their mental development, and the thyroid body normal. No known treatment is of any value.

Osteo-genesis imperfecta (or **idiopathic psathyrosis**) is a rare *congenital* condition, characterized by a defective development of osseous tissue from cartilage, so that the bones are brittle or soft, and thus are easily bent or broken, constituting a condition of fragilitas ossium. Nothing is known as to ætiology, except that there is a strong hereditary tendency. Not a few of the subjects are stillborn, with broken or deformed limbs, whilst many die within the first year of life. Cases in which fractures occur more or less spontaneously and frequently in older life are probably due to some other condition, such as osteo-malacia. If the child lives, one fracture occurs after another, and the limbs may become terribly deformed, although with care they sometimes unite very well. In addition to the deformities due to the malunion of fractures, the bones are usually bent and distorted, and thus the case may be confused with rickets or osteo-malacia. The cranial bones sometimes participate in the process, and the basi-occiput may be driven upwards into the cranial cavity by the thrust of the spine; this condition is demonstrable by radiography. The actual anatomical changes in the bones consist in the persistence of cartilage cells in their capsules and calcification of the trabeculæ between, very little bone being formed and that of a defective type. No known remedies are of any avail, and all that can be done is to protect the patient from mechanical injuries and treat the fractures as they occur.

Mollities Ossium (*syn.* : **Osteo-malacia**) is an *acquired* disease of somewhat unusual occurrence, characterized by the absorption of the osseous substance of the bones, as a result of which softening and rarefaction are produced, followed by bending or spontaneous fracture.

The complaint is almost limited to the female sex (only 8 per cent. of the cases reported are in males), and often commences during pregnancy; it is said to be sometimes connected with a rheumatic tendency. Any part of the skeleton may be affected; in females the change usually attacks the pelvis, spinal column and ribs first, and the limbs later; in men the process starts in the long bones.

Pathologically, the change consists in a replacement of the medullary substance by a soft fibro-cellular tissue, which is exceedingly vascular, and into which hæmorrhage often occurs; the resulting material looks in the fresh state somewhat like splenic pulp. The bony cancelli are absorbed, as also the greater part of the compact tissue, with the exception of a thin layer situated beneath the periosteum; in a well-marked case the mineral salts may be diminished to about one-sixth of their normal amount, but the relative proportion of phosphate of lime to the carbonate is not changed. Part of the bone substance remains for a time in a decalcified state, with the corpuscles evident, but in a condition of fatty degeneration. Possibly some acid—*e.g.*, lactic acid—is the active agent in dissolving the earthy salts, which escape partly in the urine, partly in the fæces. The process is probably connected with the absorption of some internal secretion, normal or vitiated, particularly that from the ovary, since the removal of the uterine appendages has in a few cases stayed the disease.

Clinically, the onset is somewhat indefinite, the only complaint being of pain in various parts of the body, whilst the patient becomes emaciated and exhausted. Sooner or later skeletal changes ensue and demonstrate the character of the disease. In women the mischief usually commences in the pelvis, which becomes flattened at first, and subsequently triradiate, owing to the acetabula being pressed inwards and backwards by the weight of the body, and in pregnant women this may cause so much deformity as to necessitate Cæsarian section. The spine becomes curved, whilst the limbs bend and break; in the latter case sometimes no attempt at repair is made, or healing may occur with deformity. Death may result from exhaustion, or from obstruction to parturition, or the patient may live more or less bedridden for years, the limbs becoming useless, shortened, and perhaps contorted in a strange and abnormal fashion. In women the disease may cease to progress, or even recovery may occur at the menopause.

Treatment is unsatisfactory. Opiates may be administered to relieve pain, which is often very severe, and various drugs, such as alum, and phosphate or hypophosphite of lime, have been recommended. In cases not associated with parturition or pregnancy, oöphorectomy is said to have been employed with benefit. The induction of premature labour is considered by some to be beneficial, not only for the sake of obviating the necessity for such operations as Cæsarian section, but also on the chance of checking the disease

Osteitis Deformans.

Osteitis deformans is an inflammatory disease of the osseous skeleton, first described by Sir James Paget in 1876. The onset is insidious, and the progress very slow. It is characterized by a painful overgrowth of the long bones, spine, cranium, and pelvis, which are also softened, so that those which bear the weight of the body become curved. It may commence in one bone alone, and then usually the tibia or femur, but more often many bones are affected at the same time. Attention may be drawn to the condition, either by the pain, which the patient at first considers to be rheumatic, or by the general enlargement and bending of the bones, or by the increased size of the head, necessitating the use of larger hats. The cranial overgrowth is eccentric in character, and the calvarium may become very thick; the facial skeleton, however, is not much affected. The spine becomes markedly kyphotic (Fig. 280), the dorsal curve being increased, and the lumbar concavity obliterated; it is nearly rigid from ankylosis of the vertebræ, and may be very painful. In the later stages the head is carried forwards by the bent spine, the height is diminished, the shoulders are round, and the chest sunken towards the pelvis; the gait is slow and awkward. The disease usually attacks middle-aged men; its progress is exceedingly slow, the patient often living to an advanced age, or dying from some intercurrent malady. Some cases have terminated in multiple sarcomata of the bones. The structure of the osseous tissue is suggestive of inflammatory rather than degenerative changes. It is softer and more uniform in structure than usual, the difference between the cancellous and compact tissue being less defined; the Haversian canals are large, and arranged irregularly, whilst the bony substance looks chalky.

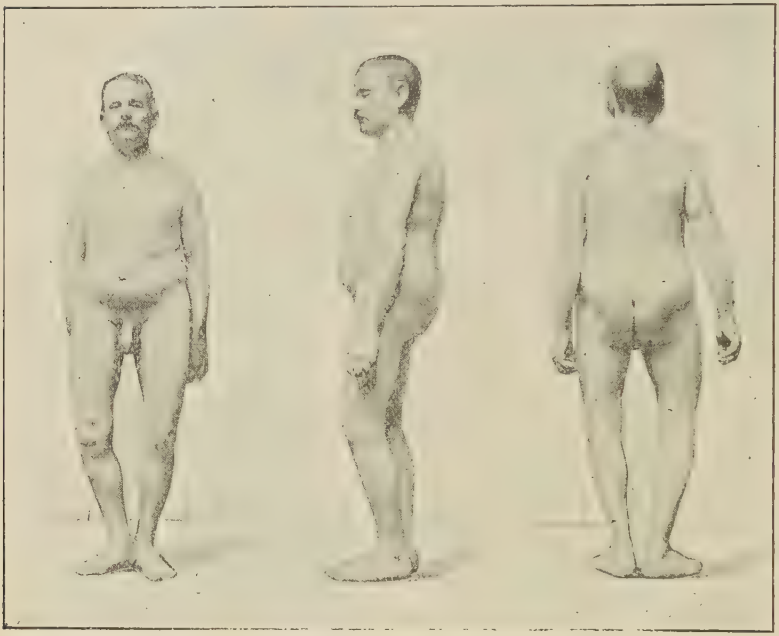

FIG. 280.—EARLY STAGE OF OSTEITIS DEFORMANS. (FROM PHOTOGRAPHS.)

Differential Diagnosis.—From *arthritis deformans*, which it resembles by the attitude and gait of the patient, it is known by the absence of articular lesions, especially in the fingers, and the enlargement of the bones, notably of the cranium. From *acromegaly* it is distinguished by the absence of enlargement of the hands, feet, and lower jaw.

Treatment is most unsatisfactory, no remedy at present known having any control over the disease.

Acromegaly.

Acromegaly is a rare condition, the characteristics of which were first described by Dr. Pierre Marie in 1885. It is a general affection involving mainly the osseous system, commencing usually in young adults, and, after lasting for a long time, killing the patient by syncope or cerebral compression, if some intercurrent malady does not destroy him.

It is characterized by a very definite enlargement of the hands and feet, which are, however, not lengthened, so that the hands have been compared to battledores, and the fingers to sausages. The bones themselves are enlarged, and the soft structures on the palmar aspects project as pads. The nails and skin are unchanged, whilst the other segments, both of the upper and lower limbs, are usually unaffected, though sometimes considerable overgrowth in length occurs; in fact, many of the so-called giants who have been exhibited are typical illustrations of acromegaly. Both the upper and lower jaws are thickened and prominent, whilst the lower lip is enlarged and overhanging. The orbital ridges project, and the forehead is usually low; the nose and tip of the tongue are also more or less enlarged. The spine is kyphotic in the dorsal region, with a slight lumbar lordosis. The ribs and sternum project anteriorly.

The patient usually suffers from headache, lassitude, and great fatigue, wandering pains about the body, and excessive appetite and thirst; amenorrhœa is a marked symptom in women, whilst men suffer from a loss of virile power. The urine is abundant, but of a low specific gravity. Vision is usually diminished, and optic neuritis has been observed in some cases.

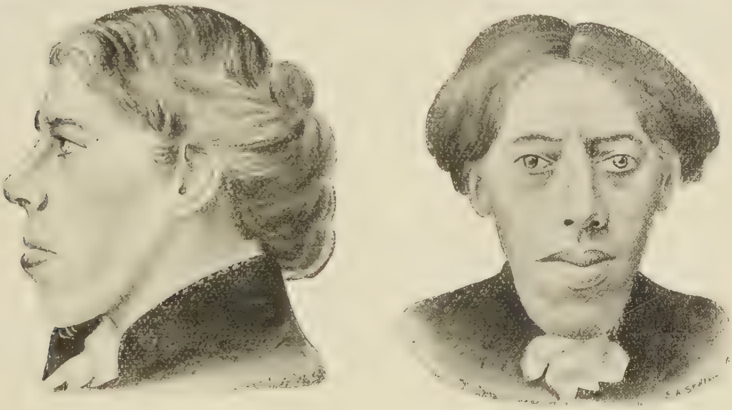

FIG. 281.—HEAD OF WOMAN WITH ACROMEGALY. SEEN FROM THE FRONT AND FROM THE SIDE.*

Morbid Anatomy.—The cause of acromegaly appears to be overgrowth of the anterior half of the pituitary body, and excessive absorption of its secretion (hyperpituitarism). The sella turcica is expanded, and this can be recognised by X rays. The changes in the bones are merely those of overgrowth.

Diagnosis.—The disease has been mistaken for *myxœdema*, but there is not much difficulty in distinguishing the two if it be remembered that, in the latter condition, the skin is not mobile over the thickened subcutaneous tissue, that the face is broad, pasty, and puffy, and that masses of gelatinous tissue are found above the clavicle, whilst in acromegaly the face is elongated and the skin and subcutaneous tissues normal. The mental condition and speech of a patient suffering from myxœdema are widely different from those in acromegaly; whilst in the former the thyroid body is either absent or diseased, and in the latter skeletal changes are present. From *chronic osteo-arthritis* affecting the hands, the diagnosis is easy, in that there are usually no signs of articular disease, and much less pain. From *osteitis deformans*, the distinguishing features have already been indicated.

Medical Treatment is merely symptomatic, antipyrine being useful in relieving the headache, as also valerianate of caffeine. Possibly thyroid extract may be of some use in combating the functional phenomena, though it will not influence the skeletal changes. Attempts have been made to remove the growth by operation through the nose and base of the skull, and with some degree of success, though naturally the mortality is high (p. 778).

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* Reproduced from the *Edinburgh Medical Journal*, by kind permission of the late Dr. G. A. Gibson.

Hypertrophic Osteo-Arthropathy.*

It has long been known that clubbing of the terminal phalanges is associated with chronic pulmonary and cardiac disease; and it is probable that such is the earliest stage of this more generalized affection, first described by Pierre Marie. In it the ends of the fingers and toes are enlarged and bulbous, with the nails curved over towards the palm or sole; in the early stages the change may be limited to the soft tissues, but radiography has demonstrated that in the later there is a well-marked new formation of bone along the shafts of the phalanges and also of the metatarsal and metacarpal bones. There is a considerable swelling of the bones just above the wrists and ankles, extending some way along the shafts, and similar bony enlargements sometimes occur elsewhere; they are due to a diffuse osteo-periostitis. The spine is kyphotic in the upper dorsal region, but with well-marked lordosis below. It is thus seen that the changes are somewhat like those of acromegaly, from which they are distinguished by (*a*) the implication chiefly of the fingers and toes, and particularly of the terminal phalanges, whilst in acromegaly the enlargement of the different portions of the hands and feet is general; (*b*) the nails are not affected in acromegaly; (*c*) the joints are but little involved in acromegaly; and (*d*) the enlargements of face, tongue, jaw, etc., so marked in acromegaly, are absent in osteoarthropathy. These phenomena probably result from chronic toxic absorption, since the condition arises in such diseases as chronic bronchitis, bronchiectasis, and chronic empyema, where suppuration has existed for some time. It is, however, sometimes associated with lesions other than pulmonary—*e.g.*, chronic jaundice, syphilis, and even influenza, and has even been found in otherwise apparently healthy individuals. Little can be done in the way of treatment, except to deal with the cause, if obvious.

Tumours of Bone.

The characters of the osteomata, chondromata, and fibromata of bone have been described in Chapter IX., and various solid and cystic tumours connected with the teeth are dealt with elsewhere.

Myeloma (Fig. 283) is practically a benign tumour, rarely giving rise to secondary deposits either in lymphatic glands or viscera, and its growth within the bone is strictly limited, with no tendency to diffusion along the medulla; occasionally a layer of condensed bone demonstrable by radiography forms an effective barrier in this direction. For its pathological features, see p. 211. The sites of election for myeloid tumours are the growing ends of the long bones, especially the lower ends of the femur and radius, and the upper ends of the humerus, tibia and fibula, whilst they also occur in the diploë and lower jaw, and constitute one form of epulis. The development of the tumour leads to the so-called *expansion* of the bone, in which the osseous tissue is absorbed from the inner aspect, and new bone is laid down externally; the outer layers, however, gradually become thinned, so that after a time the osseous lamina can be pressed inwards, giving rise to a feeling known as ' egg-shell crackling'; and finally the tumour projects through the bony wall. This expansion may be central, and the bone end thus becomes more or less globular, or it may be eccentric, and then the growth projects merely on one side. Sooner or later spontaneous fracture is likely to occur. Neighbouring joints usually escape, but in old-standing cases the growth may project around the articular cartilage and somewhat impair the movements; there may, however, be some serous effusion in the cavity. The **Symptoms** may be so slight at the commencement that nothing is noted until fracture has taken place; but sometimes pain similar to that of a chronic osteo-periostitis draws attention to the enlargement of the bone. Radiographic examination reveals a well-defined area of bone which is unduly translucent, but with a characteristic 'stippling,' due to the presence of calcareous foci scattered through the growth (Fig. 282). The accurate limitation of the growth, and its demarcation from the medullary cavity, are important diagnostic signs.

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* See Janeway, *Amer. Journ. of Med. Sci.*, October, 1903.

Treatment is governed by the assurance that a myeloma is non-malignant, and hence may be dealt with in a conservative manner by a localized removal of the growth, amputation being reserved for the more advanced cases and for those where a local removal would leave a more or less useless limb. In quite the early stages it suffices to incise the growth and scrape it away with a sharp spoon, disinfecting the cavity with liquefied carbolic acid, and packing it with gauze to ensure healing by granulation. Exposure of the part to radium or X rays is desirable in order to ensure total destruction of any remaining portions of the growth. In a later stage the affected portion of the bone must be completely removed, and if necessary the gap thus produced bridged by bone grafting. Thus a myeloid tumour of the upper end of the fibula can be treated by excision, care being taken of the external popliteal nerve and its branches, but if the upper end of the tibia or lower end of the femur is involved, amputation will usually be required, although bone grafting may be sufficient to make good the defect. When affecting the lower end of the radius or upper end of the humerus, and not in too advanced a stage, an attempt may be made to save the limb by excising the diseased portion of bone. In the wrist the lower part of the ulna is taken away, as well as the growth in the radius; by this plan there is less chance of the hand being drawn up and abducted, and hence

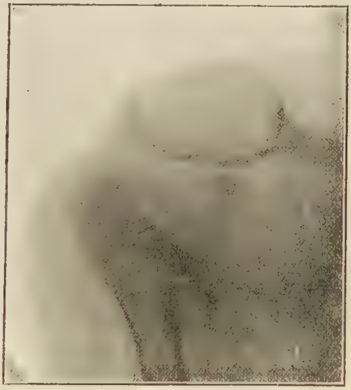


FIG. 282.—RADIOGRAPH OF MYELOMA OF OUTER END OF CLAVICLE. (BY FAVOUR OF DR. SALMOND.)

it is more likely to be of use subsequently, especially if a leather gauntlet is worn.

Sarcoma is the most important primary tumour of bones, and almost any variety may occur. The microscopical characters have been detailed in the chapter on tumours, and we shall here chiefly refer to their *clinical characteristics*. They may be divided into two main groups—the endosteal or central, and the periosteal.

Central Round- or Spindle-celled Sarcoma is of an extremely malignant nature. There is usually more pain in its development, which is much more rapid than with a myeloid growth, but the bone may be but little expanded (Fig. 284), since the growth tends rather to diffuse itself along the medullary cavity, and encroaches more closely upon the neighbouring joint. The outer wall is likely to be absorbed earlier than in a myeloid, and invasion of the surrounding tissues or spontaneous fracture results. Lymphatic glands and viscera are soon involved by dissemination of the disease. The tumour substance itself is usually of a soft nature, not containing much newly-formed bone; cartilaginous and myxomatous foci are often associated with it. The growth is highly vascular, and cysts may form therein, but not so frequently as in the myeloid tumours.

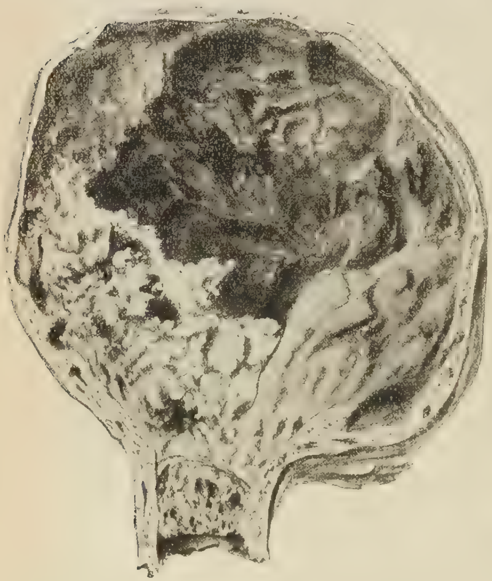


FIG. 283.—MYELOMA OF HEAD OF TIBIA. (KING'S COLLEGE HOSPITAL MUSEUM.)

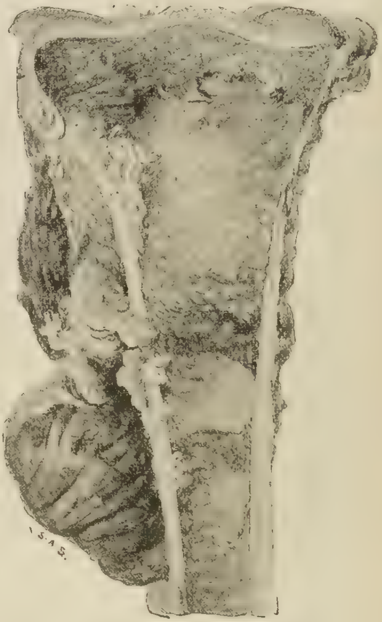


FIG. 284.—ROUND-CELLED ENDOSTEAL SARCOMA, DISSEMINATING ITSELF IN THE MEDULLARY CAVITY. (KING'S COLLEGE HOSPITAL MUSEUM.)

Radiography shows an irregular removal of bony tissue, and there is no sharply defined limiting zone of thickened bone (Fig. 287). The rapidity of growth and the radiographic characters are the features on which a diagnosis of a malignant endosteal sarcoma must be based.

Periosteal Sarcomata are round- or spindle-celled in nature, and occur less frequently than the endosteal variety. They often develop rapidly without giving rise to much pain, unless causing erosion of the bone. They usually start on one side, but may surround the whole circumference later on, and spread for some distance along the shaft. A high degree of malignancy is attained by them, secondary growths forming in lymphatic glands or the viscera. Ossification often occurs in their substance with or without the previous development of cartilage, and in such cases the subjacent bone may become sclerosed and thickened, so that spontaneous fracture is not common in this variety. The bony skeleton of such a growth is very characteristic, consisting of fine spiculated trabeculæ, radiating more or less regularly from the surface, and looking in the dried state somewhat like asbestos (Fig. 286). These ossifying sarcomata have a very characteristic appearance on radiography (Fig. 288). When a periosteal sarcoma does not become

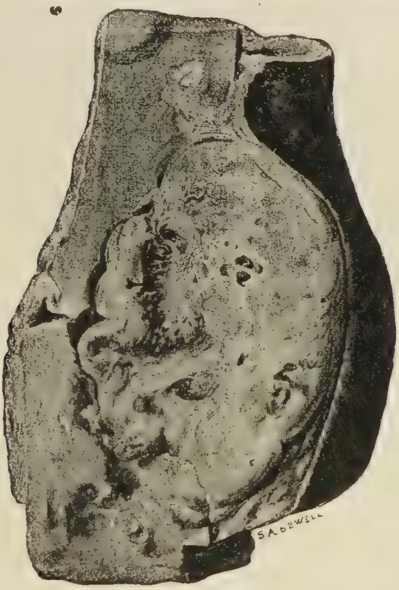


Fig. 285.—Soft Periosteal Sarcoma of Lower End of Femur, eroding Bone and leading to Spontaneous Fracture. (King's College Hospital Museum.)

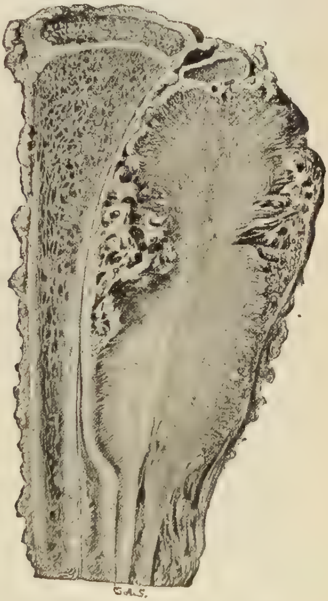


Fig. 286.—Ossifying Periosteal Sarcoma of Fibula. (King's College Hospital Museum.)

ossified, the growth often erodes the underlying bone (Fig. 285), and may lead to spontaneous fracture; the tumour in such cases is softer and more elastic than in the former variety, and usually attacks the bone from one side and not equally all round. Osseous sarcomata are always exceedingly vascular, and may even pulsate, whilst the superficial veins are obviously dilated beneath the stretched integument, giving rise to a blue network.

The **Diagnosis** of osteo-sarcoma in the early stages is often a matter of the greatest difficulty. The endosteal form may easily be mistaken for chronic osteo-periostitis, medullary gumma, or a deep abscess of the bone, and can sometimes only be distinguished from them by an exploratory incision and microscopic examination of a portion of the growth; this should always be undertaken in doubtful cases prior to radical operations, such as amputation. In the later stages, the presence of 'egg-shell crackling' or cystic changes will help to make evident the nature of the disease. The periosteal form may at first be looked upon as a periosteal node, or a deeply-placed abscess. The rounded and definite edge of the growth, its

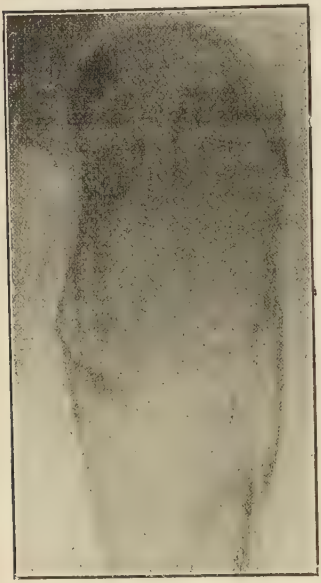


FIG. 287.—RADIOGRAM OF ENDOSTEAL SARCOMA OF UPPER END OF HUMERUS, BURROWING ALONG THE SHAFT AND CAUSING SPONTANEOUS FRACTURE.

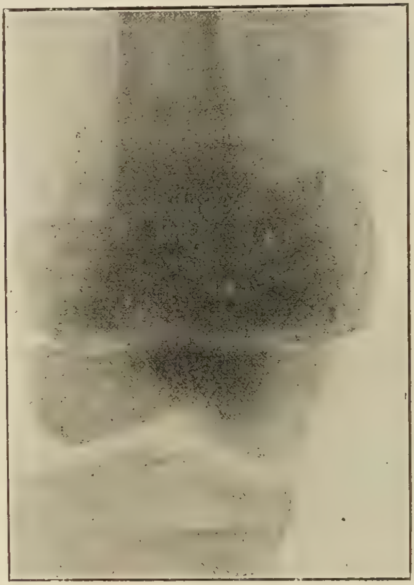


FIG. 288.—RADIOGRAM OF PERIOSTEAL SARCOMA OF LOWER END OF THE FEMUR.

The irregular outgrowths of ossific material are very characteristic, as also the limitation of the growth to the diaphysis.

irregular consistency, and the history of the case, will assist in the determination of its nature; but in the early stages an exploratory operation is not unfrequently necessary. For the diagnosis of a pulsating sarcoma from an aneurism, see p. 312. When either form involves the articular end of a bone, especially the lower end of the femur, it may simulate tuberculous disease of the adjacent bone. It will, however, be noted that the centre of the swelling corresponds to a point well above or below the joint, that a certain amount of movement is possible and even painless, whilst the starting pains at night characteristic of joint mischief are absent. The age of the patient, and the presence or not of cachexia, are also important features which have to be taken into consideration. Radiographic examination serves in most cases as an important diagnostic adjuvant.

It is of the greatest importance that a clear opinion as to the diagnosis be made at the earliest possible moment, as thereby both prognosis and treatment are immensely influenced. Periosteal sarcomata have a bad **prognosis,** as general dissemination occurs early; the small spindle-celled are the worst. Secondary deposits often contain ossific material—*e.g.*, in the lungs. Central sarcomata are not quite so malignant, although the round-celled variety is decidedly unfavourable.

The **Treatment** of osteo-sarcoma is eminently unsatisfactory, as, even though the most radical measures are taken, recurrence is only too frequently observed, or death from secondary deposits occurs in spite of a successful issue locally; hence the importance of a thorough investigation, and, if need be, of an early exploratory incision in doubtful cases, cannot be over-estimated. Formerly, the rule that governed surgical practice was to amputate the limb well above the growth in all cases, and to ascertain by microscopic examination of the medulla at the time that it was free from disease. Thus, for a tumour of the lower end of the tibia, amputation through the knee would be practised; if the upper end of the tibia is involved, amputation through the middle of the thigh; and for a growth of the lower end of the femur, disarticulation at the hip-joint would be required for a periosteal growth, though for an endosteal one just below the trochanters might suffice. For a sarcoma of the upper end of the humerus, disarticulation of the shoulder was thought to be scarcely sufficient; it was usually considered wiser to remove the scapula in addition (interscapulo-thoracic amputation).

The results of such treatment have been so bad, and dissemination of the growth to the lungs so constant, that surgeons are now doubting the desirability of such mutilating procedures, and trusting rather to the effects of local excision, where feasible, followed by treatment with radium, X rays, or Coley's fluid. In some cases disappearance or diminution of the primary growth have been reported after burying radium in its substance for twenty-four or forty-eight hours, but, of course, this does not in any way touch the question of secondary deposits. From an early diagnosis, and that alone, can any improvement be expected in the terrible statistics of the results of treatment of this dreadful disease.

Secondary Sarcoma of bone is by no means uncommon. It is almost always endosteal in character, and, except in the most unusual circumstances, will not demand treatment, owing to the general infection of the system. Possibly where it has led to spontaneous fracture, and there is much pain owing to the difficulty of fixation, it would be justifiable to remove the limb.

Carcinoma of bone is always secondary in nature, although it may be involved by direct extension in a primary growth. Secondary growths are endosteal in character, and often extremely painful; they may occasionally lead to spontaneous fracture (Fig. 289), but the bone may consolidate again satisfactorily. After scirrhus mammæ, the upper end of the femur and vertebræ are the bones most often affected, apart from those of the chest wall.

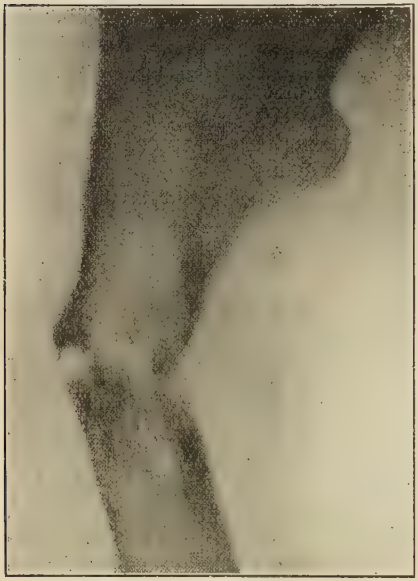


FIG. 289.—RADIOGRAM OF SECONDARY CARCINOMA OF UPPER END OF FEMUR, RESULTING IN SPONTANEOUS FRACTURE.

The primary disease was in the breast.

For the so-called **Thyroid Cancer** of bone, see p. 894.

Pulsating Tumours of Bone, or Osteo-Aneurism.—Apart from pulsating sarcoma, two other conditions are met with, in which distinct pulsation is also noticeable. In the first of these the medullary cavity is occupied by a non-malignant vascular tissue, practically identical with what has been already described as an *aneurism by anastomosis* (p. 355). Such tumours are situated most frequently in the cranial bones, and may be multiple, the medullary tissue being in consequence atrophied, and the compact tissue thinned, so that 'egg-shell crackling' may be obtained. The second form is found most commonly in the upper end of the tibia, or some such cancellous mass. It consists of a hollow cavity, filled with blood. Several distinct arterial twigs may open into it, and the overlying bone is thinned and absorbed. It is probable that the majority of such cases are in reality due to the breaking down of a sarcoma of extreme tenuity, or possibly of a myeloma.

Treatment.—If it seems probable that the condition is not associated with malignant disease, the cavity should be incised, scraped, swabbed out with pure carbolic acid, and then firmly packed with gauze, so as to obtain healing by granulation from the bottom. If the bleeding persists, amputation is the only treatment, as also in the malignant cases.

Hydatid Disease of Bone.—The cancellous tissue of bones occasionally becomes the site of hydatid development, any part either of the medullary cavity or of the ends being involved. The bone becomes expanded, with all the symptoms of an endosteal growth. Considerable deformity may occur, and when the compact layer has been sufficiently absorbed, spontaneous fracture may follow. In this affection there is no limiting wall, the small daughter cysts being diffused through the affected area. A diagnosis is little likely to be made (at any rate in countries where hydatid disease is rare) prior to an exploratory incision. **Treatment.**—If all the cysts can be removed without interfering with the integrity of the shaft, a recovery, with good subsequent utility of the limb, should follow. Where, however, the disease has encroached widely on the bony tissue, whether spontaneous fracture has occurred or not, amputation holds out the only prospect of cure, unless bone-grafting is feasible.

Simple Cysts of Bone are observed most frequently in the tibia or upper end of the humerus. The condition develops insidiously, probably without pain, and may be mistaken for a sarcoma, the true state of affairs not being recognised until after amputation of the limb; or attention may be drawn to the part by the occurrence of a spontaneous fracture. The cyst is found to be lined with a thin layer of fibrous tissue, with no endothelial covering. The actual pathology is not clear, but it is thought possible that it is akin to osteitis deformans or osteo-malacia, since in all three conditions the true bony tissue disappears and the medullary tissue increases. In osteo-malacia it remains fatty; in osteitis deformans new irregular bone is deposited in its place; and, in this condition there is a new formation of fibrous tissue, which, however, subsequently becomes cystic. This *osteitis fibrosa*, as it has been termed, may be more or less generalized through a bone, or may be localized, and then a simple cyst may develop. The only available means of diagnosis, apart from incision, is radiography. The thinning of the bone is more regular than in any sarcomatous condition, and there is a complete absence of mottling or detail such as is usually seen in cases of myeloid disease. **Treatment** consists in laying open the cavity, scraping it out, and packing, so as to determine healing by granulation; or by excising the affected portion of bone, and replacing it by a bone graft.

Bone-grafting is sometimes required to replace the normal bone in cases of comminuted fractures where much destruction of tissue has occurred, or after resection of portions of the shaft of a bone for tumours, cysts, or caries.

Formerly fragments of dead bone, or rods of ivory or bone, were used for the purpose, but it has been abundantly proved that they are merely passive actors in the process of regeneration, being absorbed or replaced. Living bone, on the contrary, is capable of retaining its vitality and uniting with the surrounding parts, even if totally separated from its former osseous connections.

Much discussion has arisen as to whether the bone graft should be covered by periosteum or not. Some claim that a graft with its periosteum intact has a greater chance of living and uniting with the adjoining bones than one devoid of periosteal covering, because, although it is believed that the periosteum itself takes no active share in new bone formation, it conveys nutrition to the graft and obtains a fresh blood-supply from its new surroundings more rapidly than does uncovered bone, and thus secures the vitality of the graft. This idea, however, is quite open to question, since it is possible that naked bone is more porous and permeable to newly-formed vessels than periosteum. As a matter of fact, excellent results have been gained in both ways.

The graft may be obtained from the patient himself (*autogenous*), or from another patient (*homogeneous*), or from a freshly killed animal (*heterogeneous*). Of these, the first method is usually adopted, and at present it gives the best results. The bone is usually taken from the surface of the tibia, or a portion of the whole thickness of the fibula. It is generally employed in a long strip, and the practice of breaking it up into small fragments has no obvious advantages except in special circumstances, as after trephining. The graft is, if possible, fixed firmly to the two bony ends, between which a bond of union is required, either by implantation into the suitably prepared medullary cavities, or by means of catgut or silk sutures. Metal plates, wires, or screws are undesirable means of fixation. New bone can also live when implanted in the midst of soft tissues, as is evident from grafts surviving which have been utilized in the re-formation of a nose. Of course, in all cases absolute asepsis, both of the graft and of the cavity in which it is placed, must be present, and therefore it is useless at once to attempt bone-grafting in the cavity left by the removal of the diaphysis after an attack of acute osteomyelitis which has caused necrosis of the whole shaft. When once the cavity is free from infection, a bone graft may be introduced with some prospect of its survival.

CHAPTER XXII.

INJURIES OF JOINTS—DISLOCATIONS.

Sprains and Strains result from sudden violence applied to a joint either directly or indirectly, as in the football field or in many laborious occupations. They consist in a tearing or stretching of the synovial membrane, partially detached portions of which may be tucked inwards, or of ligaments, which in bad cases may be torn from their attachments to the bones. The accident itself is associated with severe pain, and is immediately followed by more or less hæmorrhage into the surrounding tissues, or into the articular cavity. Inflammatory effusion follows, and unless suitably treated, persistent weakness and pain may result, either from the formation of adhesions, or from imperfect repair. A neglected sprain may originate tuberculous disease in those who are so predisposed, whilst osteo-arthritis is by no means an uncommon sequela. If the patient is in a bad state of health at the time of the injury, an attack of acute infective arthritis may be determined. **Treatment.**—The joint should be firmly supported by a wet bandage as soon after the accident as possible, in order to limit the amount of effusion. The part is raised and kept quiet, and the bandage dabbed over with evaporating lotion from time to time. In the slighter cases the patient may be allowed to use the limb in a few days, the part being supported by strapping or an elastic bandage; but in severe sprains it may be necessary to keep the part absolutely at rest for a much longer period, before the pain and tenderness disappear. Friction with stimulating liniments, douching the joint alternately with hot and cold water, massage, passive and active movements, and finally exercises against resistance, are useful in restoring the limb to full functional activity.

Penetrating Wounds of Joints are often accompanied by an escape of synovia, which is recognised as a glairy, oily fluid, floating perhaps on the surface of the blood; if, however, the aperture is small, this may not occur. It is always followed by a certain amount of reaction, the character of which depends on whether or not the joint is infected. If no infection has taken place, a simple synovitis ensues, but soon passes; if, however, infection has occurred, acute arthritis probably supervenes, leading to disorganization of the joint. (For symptoms and treatment, see p. 634.) A penetrating wound, even if untreated, does not necessarily become infected; thus, if the lesion is produced by a small, clean instrument, and especially if this is inserted in a slanting direction, so that the wound is valvular, or if the incision is a large one, allowing free vent to all discharges, recovery without infection is possible.

Treatment.—If the wound is small, and there is reason to believe that the instrument inflicting it was aseptic, the external skin should be thoroughly purified, and an antiseptic dressing applied. A careful watch must be kept upon the condition of the joint and upon the temperature of the patient; as soon as any signs of acute arthritis manifest themselves, free incisions are made into the joint, so as to relieve tension, and allow the cavity to be irrigated. If, however, the wound is dirty, and probably involves the joint, it should be enlarged so that its depths may be purified, and then carefully examined. If it is found that the cavity has been opened, the aperture should be increased in size so as to allow it to be washed out and a drainage-tube inserted. Bier's treatment may assist in preventing infection, but if it supervenes, the condition must be treated in the usual way.

Dislocations.

Congenital Dislocation.—This term is applied generally to any irregularity of location of the bony constituents of a joint present at birth, but is rather due to an error of development than to any forcible displacement. The hip-joint is most frequently affected; but similar malformations have occurred in the shoulder, wrist, and jaw, whilst the patella may be congenitally absent or displaced. For *congenital dislocation of the hip*, see p. 447.

Pathological Dislocations are produced as the result of some intra-articular affection, *e.g.*, tuberculous disease, osteo-arthritis, Charcot's disease, etc. It is unnecessary to describe them here.

Traumatic Dislocations.—The **Causes** are divided into predisposing and exciting. Under the former head may be included anatomical peculiarities, such as the shallow socket of the glenoid cavity, or some muscular or ligamentous weakness. Dislocations are rare in children, since any violence directed to a joint or its neighbourhood is more likely to lead to an epiphyseal separation. Moreover, in old people the bones become brittle, and thus fractures, rather than dislocations, are produced; hence the latter lesions are almost limited to adults, and, owing to their greater exposure to injury, occur in men rather than in women.

The **Exciting Causes** are the application of external violence and muscular force, acting alone or in combination. The former may be direct, but is more commonly indirect, the force being applied at a distance from the joint. Muscular action by itself can only produce dislocation in certain joints; the head of the humerus, the patella and condyle of the jaw, are the bones most often affected in this way. If, however, the ligaments of a joint have been stretched by previous disease or displacement, recurrent dislocations from muscular action are not unusual.

The term *complete dislocation*, or *luxation*, is applied to that condition in which the articular surfaces of the bones are completely separated from one another. An *incomplete dislocation*, or *subluxation*, is one in which the surfaces are only partially separated.

A *compound dislocation* is one in which the skin has been ruptured and a communication established with the external air. A *complicated dislocation* is one in which there has been some associated injury of vessels, nerves, or viscera. The term *fracture-dislocation* is one applied to a condition in which a dislocation is complicated by fracture of one or both bones involved.

The **Signs** of a dislocation are as follows: (1) The evidences of a local trauma, *e.g.*, pain, bruising, and swelling of the soft tissues, due to their laceration and the effusion of blood into them: the amount of this varies in different cases; (2) deformity of the limb, due to the articular end of the displaced bone being in some abnormal position, where it can often be felt and sometimes seen; and (3) restricted mobility of the affected joint, and hence impairment of function of the limb. The degree to which this latter phenomenon obtains is necessarily variable, but as a rule it is very marked; if, however, fracture is also present, passive movements may be possible, though associated with pain and crepitus.

The **Effects** produced by a dislocation extend to all the structures entering into and surrounding the site of injury. The ligaments are partially or completely torn; the bony surfaces are not unfrequently fractured, especially in closely-fitting hinge joints, such as the elbow and ankle; the cartilages may be bruised, or portions of them detached, and neighbouring muscles and tendons lacerated and displaced; adjacent vessels and nerves are often contused or compressed. Considerable effusion of blood is always present, infiltrating the whole area involved.

The character of the injury explains the difficulties that are met with in its reduction. These arise from two main causes: (*a*) The anatomical arrangement of the joint and its ligaments, resulting in the hitching of bony prominences against one another, whilst the head of the bone does not always lie opposite the hole in the capsule through which it originally passed. In a few cases the end of the bone may be grasped by neighbouring ligaments and tendons in such a way as to render its replacement a matter of the greatest difficulty. (*b*) Muscular contraction also constitutes an obstacle, which, though it can be counteracted by suitable traction, is more effectively overcome by the use of an anæsthetic. Not only does the patient maintain the limb in a condition of rest by a voluntary tonic contraction, but it becomes fixed by the involuntary passive tension of the displaced muscles.

When once reduced, there is usually but little tendency for a dislocation to recur. Reparative changes quickly manifest themselves; blood-clot is absorbed, the rent in the capsule closes by cicatrization, and in many cases no permanent lesion remains; in some, however, the joint is left in a weak and relaxed state, and liable to a recurrence of the displacement, while intra-articular adhesions, or the cicatricial contraction of the injured ligaments and muscles, may cause some loss of mobility.

If a dislocation is *allowed to remain unreduced,* the true articular cavity becomes shallow and partly filled up by a transformation of its cartilage into fibrous tissue, whilst the displaced head of the bone becomes adherent to the structures amongst which it lies; as the result of a plastic inflammation, either dense fibrous adhesions are formed, or a new false joint (*pseudarthrosis*). The articular cartilage is eroded, and the exposed bone eburnated and sclerosed, whilst, owing to chronic periostitis, the end of the shaft may be considerably deformed. The portion of bone upon which the displaced head rests undergoes changes, partly atrophic (from pressure), partly hypertrophic (as a result of chronic periostitis), whereby a new socket is produced (Fig. 290). Neighbouring muscles are secondarily shortened, and accommodate themselves to the abnormal position of the limb, and tendons which have been torn gain fresh attachments. These changes necessarily interfere more or less seriously with the power of the limb and the movements of the joint. Serious pain is not unfrequently caused by pressure on neighbouring nerves.

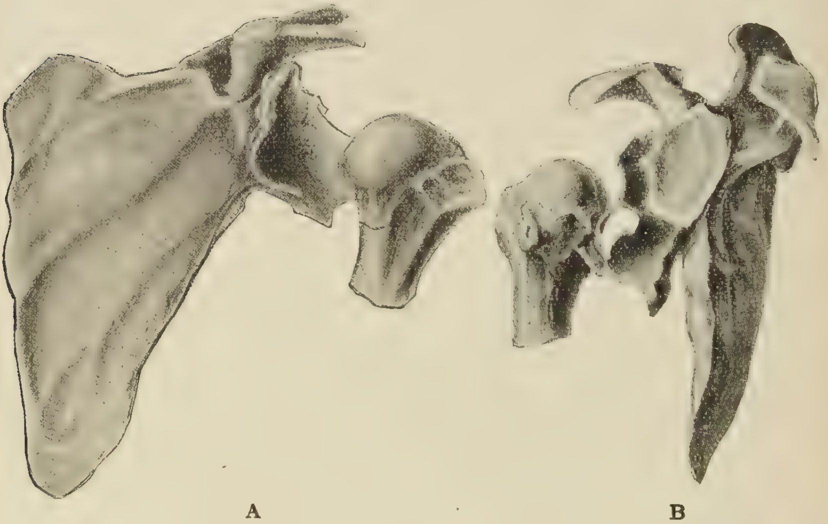


FIG. 290.—OLD-STANDING SUBCORACOID DISLOCATION OF THE SHOULDER, SHOWING ATROPHY OF TRUE GLENOID CAVITY, TOGETHER WITH FORMATION OF NEW JOINT AND ALTERATION IN SHAPE OF HEAD OF BONE. (FROM COLLEGE OF SURGEONS' MUSEUM.)

Treatment.—The treatment of dislocations consists in the reduction of the displaced bone with as little delay as possible. There are two chief methods of gaining this end, viz., manipulation and extension.

Manipulation is always the best means to employ where practicable, less injury being sustained by the surrounding tissues. It consists in moving the limb in such directions as shall cause the displaced end to retrace the course that it has already taken, through the rent in the capsule to its normal position. The shoulder and hip joints are more amenable to this method of treatment than hinge joints. Anæsthesia will be required in difficult cases, and especially in dislocations of the shoulder and hip joints. Chloroform is generally preferred, as inducing deeper muscular relaxation, but where the patient is in a bad state for the administration—*i.e.*, with his stomach full of food—ether may be preferable. It is only right to draw attention to the fact that a large number of fatal cases of chloroform administration have been reported as occurring in the treatment of shoulder dislocations; this is due mainly to two causes, viz., the deep anæsthesia required, and the want of preparation of the patient. The greatest care must therefore be exercised in giving the anæsthetic, and for the hip-joint spinal analgesia might be preferable.

Extension is employed to overcome muscular and other forms of resistance, so as to allow the bone to slip back or be manipulated into its original position. In order to make this effectual, the parts above the dislocation are steadied by some *counter-extending* force applied either by the hands of an assistant, or by a belt or towel, or by the knee or foot of the surgeon. Extension may be made by the hands, or a firmer grip may be maintained, and greater force used, by applying a bandage or towel to the limb. In a few cases, the force may be exerted through some form of multiplying pulley, fixed at one end to a hook or staple, and at the other end attached to the limb. When any such contrivance is employed, precautions must be taken to prevent the soft tissues from being injured. A useful plan consists in applying a damp bandage at the point from which traction is to be made, and over this a thick skein of worsted in the form of a clove-hitch, the loop being attached to the hook of the pulley. The extension must be made continuously; no jolting or jerking action is allowable, or considerable mischief may ensue. Since the introduction of anæsthetics, however, pulleys have been very rarely required.

Reduction, however produced, is usually accompanied by a sudden and distinct snap or suction sound, due to the contraction of muscles, unless the patient is deeply under an anæsthetic, and the muscles are absolutely relaxed. The limb is subsequently kept at rest for some days, to allow the rent in the capsule to heal, but massage may be started in a day or two, and passive movements after a week.

The treatment of an unreduced dislocation is often a matter of considerable difficulty. Attempts at reduction *may* be undertaken up to two or three months, but the greatest caution must be employed for fear of rupturing adhesions and endangering the main vessels or nerves. Extension by pulleys has given rise to so many accidents, varying in severity from laceration of the skin to actual avulsion of the limb, that it is wise to discontinue such treatment if it has failed on its first application.

The amount of mobility possible in an unreduced dislocation varies a good deal in different cases, and the character of the treatment is mainly governed by this. If movement is tolerably free, and not particularly painful, massage and manipulation may be undertaken, and a very useful limb result. Where, however, movement is both painful and limited, one or other of the following plans of operative treatment should be undertaken: (i.) Reduction by an *open operation.* The head of the bone is cut down on, and freed from its adhesions to surrounding structures, the capsule of the joint being also opened and the cavity cleared; reduction may then be possible by means of manipulation or extension. A few cases of successful treatment of old-standing dislocations of the shoulder by this means have been recorded; but as a rule the gain derived thereby is scarcely commensurate with the risks and difficulties of the operation, especially if a considerable interval has elapsed since the accident. (ii.) *Excision* of the displaced head of the bone will give the best results in most cases. In the elbow-joint it is often the only practicable treatment, and in the shoulder and hip it is usually better than attempting open reduction.

Compound dislocations are always serious lesions, for not only are adjacent vessels and nerves liable to injury, but unless efficient treatment is adopted, suppurative arthritis ensues, leading to disorganization of the articulation, with subsequent ankylosis, or, in the case of larger joints, possibly to death from pyæmia and toxic poisoning. The *treatment* consists in rigid antisepsis to the wound, together with reduction of the dislocation and temporary drainage. If necessary, the opening in the skin must be enlarged, in order to allow of the replacement of the bone, and should the latter structure be much bruised or injured, it may be advisable to resect it at once. If, however, vessels and nerves are also injured, or if the patient is old or debilitated, amputation may be required.

Special Dislocations.

Dislocation of the Lower Jaw forwards is not a very common accident, and usually results either from muscular action, or from a blow on the chin when the mouth is widely open, as in gaping, laughing, or attempting to take a large bite. It has also been produced in dentistry by a violent strain during tooth-drawing, or from digging out roots with an elevator. In some persons the accident happens with the greatest ease, and constantly recurs, owing probably to laxity of the capsule or insufficient development of the eminentia articularis.

The *mechanism* of the dislocation is as follows: When the mouth is opened, the condyle of the jaw slips forwards on to the eminentia articularis, and it requires very little force to displace it still further into the zygomatic fossa (Fig. 291). The inter-articular cartilage follows the condyle, and the attachment of the external pterygoid muscle to that structure and to the bone explains the occurrence of dislocation from muscular action.

The displacement may be unilateral or bilateral, more frequently the latter. The mouth remains widely open, the teeth and the jaws being separated by an interval of about an inch. The lower jaw projects unduly, and is fixed, saliva dribbling over the lip; speech and deglutition are impaired, the pronunciation of the labial consonants being especially difficult. A hollow can be detected immediately in front of the tragus, where the condyle is normally lodged, and in front of this hollow the condyle can be felt, being recognised by the slight amount of passive movement still possible. A finger in the mouth may define the coronoid process in an abnormal position beneath the zygoma.

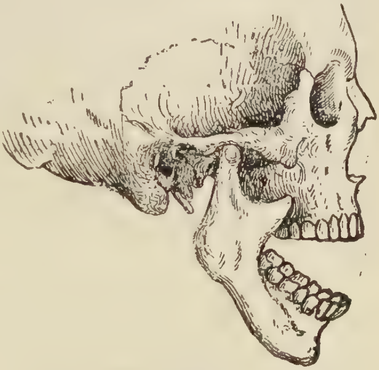


FIG. 291.—DISLOCATION OF JAW.

When the dislocation is unilateral, the symptoms are much less marked. Some amount of movement of the jaw still remains, whilst the chin is displaced towards the sound side.

Treatment.—Reduction is usually easy. All that is needed is to depress the condyle below the level of the eminentia articularis, when the masseter, temporal, and internal pterygoid muscles speedily draw it back into the glenoid cavity. The patient is seated in a chair; the surgeon standing in front protects his thumbs with thick napkins, and introduces them into the mouth, pressing upon the lower molar teeth. Pressure is continued in a downward and backward direction until the condyle is free, and then the chin is raised by the fingers on either side. The jaw is kept at rest for a week or ten days by means of a four-tailed bandage. Anæsthesia is occasionally necessary.

A few cases are on record of displacement of the condyle of the jaw *backwards*, associated with fracture of the tympanic plate and tearing or separation of the cartilage of the auricle, leading to bleeding from the ear. Displacement *upwards* into the cranial cavity through the roof of the glenoid fossa has also been described.

Subluxation of the Temporo-maxillary Joint is due to displacement of a relaxed interarticular cartilage, which becomes folded or nipped on opening the mouth, the result being a painful temporary fixation of the jaw with a snap or crack on freeing it. The condition is associated with a passive synovial effusion into the joint, and may be dealt with by the external application of blisters; should this fail, it is justifiable to open the joint and fix the cartilage by sutures or remove it (p. 813).

Dislocation of the Sternal End of the Clavicle.—In spite of the apparent weakness of this joint and the great strains to which it is subjected, dislocation is uncommon, owing to the strength of the ligaments surrounding it, particularly of the rhomboid, the clavicle being more easily broken than displaced. The **cause** of these dislocations is always violence directed to the outer end of the bone, and since that usually acts from in front, the inner end of the bone is generally thrown forwards. Two other varieties are described, however, in which the displacement is backwards or upwards.

In the **forward** dislocation the end of the bone lies on the anterior surface of the manubrium, where it can be easily detected; all the ligaments of the joint are torn, except, perhaps, the interclavicular. The point of the shoulder is approximated to the middle line. *Treatment.*—Reduction is effected by placing the knee against the spine between the scapulæ, and drawing the shoulders backwards, the elbow on the affected side being kept in front of the mid-axillary line. To prevent recurrence, the shoulders are kept back by handkerchiefs passed round the axillæ and knotted together in the middle line behind, as for a fractured clavicle (p. 501). The elbow is then drawn forwards in front of the mid-axillary line, and supported by a sling or bandage. It is advisable to keep the patient in bed for a few days, so as to give the ligaments a better chance of re-uniting, but some amount of forward displacement is very likely to persist. No bad result follows, even should the dislocation remain unreduced.

The **backward** dislocation is not often seen. The end of the bone lies behind the upper part of the sternum, and pressure upon the trachea, œsophagus, and vessels of the neck, result, giving rise to difficulty in breathing and swallowing, and to congestion of the head. Reduction and after-treatment are similar to that suggested for the former variety. If the condition cannot be reduced, and serious symptoms of pressure are present, the end of the bone should be excised.

The **upward** dislocation is one of extreme rarity, the end of the bone lying in the episternal notch behind the sterno-mastoid, and compressing both trachea and œsophagus. To effect reduction, the shoulders are drawn forcibly backwards, and direct pressure applied to the end of the bone.

Dislocation of the Acromio-clavicular Joint consists in the acromion being forced either above or below the outer end of the clavicle, more commonly the latter. The displacement is easily recognised by the abnormal prominence of one or other of the bones. It usually results from violence directed to the scapula. No difficulty is experienced in reduction, but the displacement is very liable to recur, especially in the more common form. The elbow is then flexed to a right angle, and pads of lint or small towels placed over the acromion and beneath the elbow; a bandage or strap, applied over the shoulder and under the elbow, suffices to maintain the bone in position. The strap is kept from slipping by passing a bandage under it round the opposite side of the chest. Should the displacement persist, the bones may be wired together after bringing the cartilaginous surfaces into contact. Care must be taken to prevent subsequent ankylosis by passing the wires in such a way as not to encroach on the joint surfaces. Either they may be passed through the bones vertically, or as a mattress suture from before backwards.

Dislocation of the Shoulder occurs almost as frequently as all the other dislocations of the body put together. The shallowness of the glenoid cavity, the size of the head of the humerus, the laxity of the capsule, the extent and force of the movements possible, and the exposed position of the shoulder, explain the great frequency of the accident. It usually results from falls upon the hand or elbow, the arm at the time of the accident being widely outstretched. The weak lower and inner part of the capsule first yields, the head of the bone being primarily displaced downwards into the axilla (subglenoid variety), and then, according to the direction of the force, or the character of the subsequent manipulations, the head travels either forwards (subcoracoid or subclavicular dislocation) or backwards (subspinous). Falls on the elbow or shoulder may, however, cause a direct forward or backward displacement.

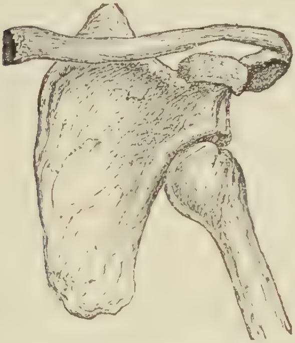


FIG. 292.—SUBGLENOID DISLOCATION OF SHOULDER. (TILLMANNS.)

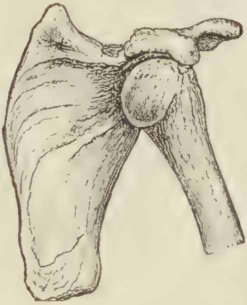


FIG. 293.—SUBCORACOID DISLOCATION OF SHOULDER. (TILLMANNS.)

The **Signs** of a dislocation of the shoulder are sufficiently obvious, and certain characteristic features are present in almost all varieties (1) The shoulder looks flattened, owing to displacement of the head inwards (Figs. 212, B, and 294), and as a result of this the acromion process is unduly prominent, and a hollow is felt below it, occupied by the tense deltoid. (2) The head of the bone lies in some abnormal position, and the glenoid cavity is empty. (3) The elbow is displaced away from the side, and it is impossible to make it touch the chest wall at the same time that the hand is placed on the opposite shoulder (Duga's test); this does not always obtain in the subcoracoid type

(4) The vertical measurement round the axilla is increased in all the varieties (Callaway's test); whilst inspection reveals a lowering of the anterior or posterior axillary fold (Bryant's test). (5) A ruler or straight-edge can be made to touch both the acromion process and the outer condyle of the elbow in most cases of dislocation (Hamilton's ruler test); this is impossible when the head of the bone is in its normal position, but can also occur in fractures of the anatomical neck. At the same time, the usual signs of a dislocation, viz., rigidity and local bruising, are also present. Stereoscopic radiography is, of course, invaluable for diagnostic purposes.

Subglenoid Dislocation (Fig. 292) is always the primary condition when due to a fall upon the outstretched arm, but is not often seen, since further displacement usually occurs before the case comes under observation. The head of the bone passes down into the axilla, resting against the outer border of the scapula below the glenoid cavity, between the subscapularis above and the teres minor below, with the long head of the triceps behind. The capsular ligament and muscles passing to the tuberosities are torn, whilst the axillary vessels and nerves may be seriously compressed, leading to numbness of the fingers. The head of the bone is felt in the axilla, and the anterior axillary fold is much lowered; the elbow is directed away from the side and slightly backwards; the arm is lengthened, perhaps to the extent of 1 inch, whilst the fore-arm is usually flexed.

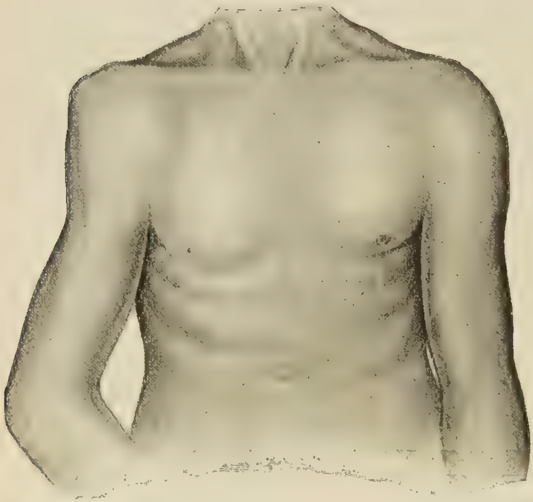


FIG. 294.—SUBCORACOID DISLOCATION OF THE RIGHT SHOULDER.

A few cases have been recorded in which the arm was abducted and displaced vertically upwards, although the head of the bone was in the usual position of a subglenoid dislocation. This variety is known as the *luxatio erecta.*

Subcoracoid Dislocation (Figs. 293 and 294) is, without doubt, the most common form. The head of the bone lies under the coracoid process on the anterior part of the neck of the scapula, immediately in front of the glenoid cavity, the anatomical neck impinging on its anterior border. In this position it is above the tendon of the subscapularis, which is either torn or stretched over the neck as a tense band, and may considerably impede reduction. The muscles attached to the great tuberosity may be stretched, resulting in marked external rotation of the limb (subcoracoid variety), or they are torn, or even the great tuberosity itself pulled off, the humerus being then rotated inwards (intracoracoid variety). The elbow is displaced backwards and outwards, and the head of the bone can be usually felt on rotation of the arm under the outer third of the clavicle. Comparatively little alteration is produced in the length of the arm.

The **Subclavicular** variety is uncommon, and merely an exaggeration of the subcoracoid. The head of the humerus passes further inwards, and lies deeply under the pectoralis minor, on the second and third ribs. The elbow is markedly separated from the side and directed a little backwards, whilst distinct shortening is present.

The **Subspinous Dislocation** (Fig. 295) is unusual. The head of the bone lies in the infraspinous fossa, immediately behind the glenoid cavity, between the infraspinatus and teres minor muscles, the subscapularis being generally torn. The elbow is displaced considerably forwards, but can be made to touch the chest wall; the arm is rotated inwards, so that the hand is thrown across the front of the body. There is usually a marked hollow in front of the shoulder, whilst a prominence is caused behind by the head of the bone in its false position. The length of the limb is frequently unaffected, or if any change is present, the arm is slightly lengthened.

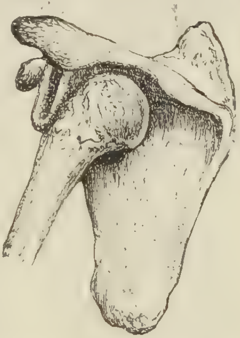


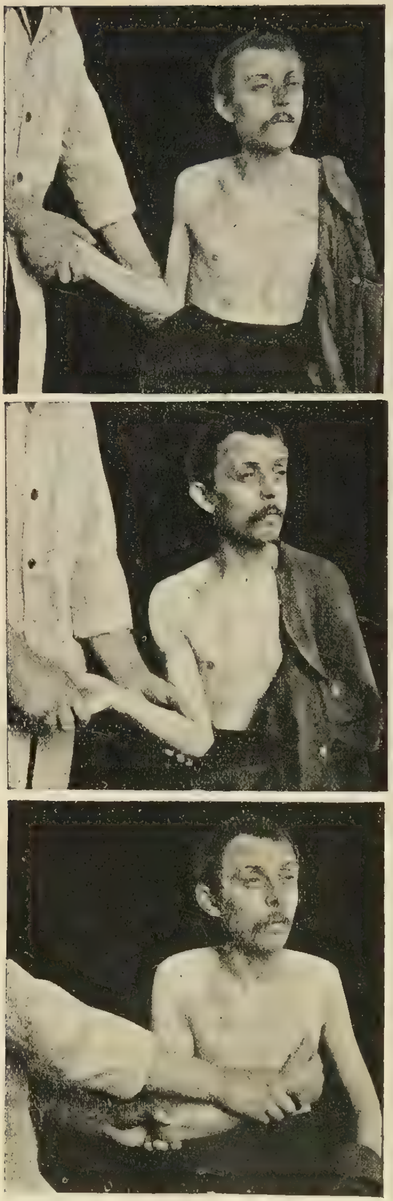
FIG. 295.—SUBSPINOUS DISLOCATION OF SHOULDER. (TILLMANNS.)

A few cases have been described of what is known as a **Supracoracoid Dislocation.** The head of the bone is displaced upwards, and either the coracoid or acromion process is broken, more commonly the former. Replacement with crepitus is easily obtained, but the dislocation is liable to recur.

The **Treatment of Dislocation of the Shoulder** consists in reduction by manipulation or extension.

1. For *reduction by manipulation* an anæsthetic is always advisable, but must be given with caution. Many different methods of manipulation have been suggested, of which the following are the more important. Not unfrequently, however, when the muscles are relaxed, any slight rotary movement suffices to 'put the bone in.'

Kocher's Method for Subcoracoid Dislocations.—The surgeon standing in front of his patient, who is seated or reclining, and supported by an assistant, grasps the elbow after flexion of the fore-arm, and



Figs. 296, 297, 298.—Kocher's Method of Reduction of a Subcoracoid Dislocation of the Shoulder.

presses it to the side and slightly backwards. With one hand holding the wrist and the other the elbow, the arm is now rotated firmly and steadily outwards as far as it will go, the elbow still being pressed to the side (Fig. 296). Distinct resistance will be felt during this movement, which causes the head of the humerus to roll out beneath the acromion, and may suffice to effect reduction. If the limb is still displaced, the elbow should be drawn forwards and upwards as far as it will go, with the humerus still fully everted (Fig. 297), whilst finally the arm is rotated inwards so as to carry the hand towards the opposite shoulder, and the elbow drawn across the chest and lowered (Fig. 298). All these movements should be carried out steadily and evenly, and without undue force for fear of fracturing the surgical neck of the bone. The value of this plan, according to Kocher, turns on the fact that '. . . the posterior part of the capsule and the scapular tendons inserted therein are usually untorn and stretched tightly across the glenoid fossa. Rotation outwards relaxes these structures and removes them from the fossa, whilst the rent in the capsule gapes; but owing to the fact that the upper and lower margins of the opening are still tight, the head of the humerus remains fixed against the neck of the scapula until the elbow is carried forwards and raised. The upper part of the capsule then relaxes, and the lower part, which remains tense, guides the head of the bone into the joint.'

Smith's Method varies somewhat in its application, according to whether the head of the bone is displaced anteriorly or posteriorly. For anterior displacements the surgeon stands in front of the patient, and grasps the shoulder, using the right hand for the right shoulder and the left for the left, so that the thumb rests on the head of the bone, and the fingers grasp and steady the scapula. With the other hand he seizes the arm near the elbow which has been flexed, and raises it from the side, extending and everting it. Having thus raised it to a right angle, the limb is steadily and continuously circumducted inwards, the thumb following the head of the bone and assisting it to reach the lower and under side of the capsule, and thus enter the socket through the rent. For the subspinous dislocation, the surgeon stands behind the patient and grasps the shoulder with one hand, raising the arm with the other, and making extension backwards combined with external rotation; *i.e.*, the limb is circumducted outwards, and finally brought to the side.

2. *Extension* may be applied in different ways, the object being to overcome the tension of surrounding ligaments and muscles. It may be applied directly downwards by the surgeon grasping and pulling on the arm, whilst his unbooted foot is used as a counter-extending force in the axilla, the patient lying flat on a mattress placed on the ground, and the surgeon sitting by the side. Another plan consists in using the knee as a fulcrum instead of the heel, the patient sitting in a chair. Occasionally the foot has been placed against the thoracic wall, and extension made directly outwards at right angles to the body, as recommended by Sir Astley Cooper. White of Manchester suggested vertical traction, the arm being pulled directly upwards, the surgeon's foot having been placed over the acromion, the patient being in the recumbent posture. The only objection to this last method, which may succeed when other plans fail, is that the axillary vessels are somewhat exposed to injury.

Dislocations of the Elbow-Joint are not very uncommon, occurring particularly in young people, and are due to either direct or indirect violence. The diagnosis is often difficult from the amount of swelling that quickly follows. A careful investigation of the relative position of the bony points (p. 510), and of the degree of mobility of the different parts on each other, is essential in order to arrive at a definite conclusion as to the exact nature of the lesion. In cases of doubt, a radiogram should be taken.

1. **Dislocation of Both Bones** may occur either *backwards*, *forwards*, or *laterally*.

The **backward** variety (Fig. 216, A) is that most often met with; it usually occurs without either the coronoid process or the olecranon being fractured, although occasionally the former is detached. If the coronoid remains intact, it sometimes becomes locked in the olecranon fossa, and renders the arm immobile; if, however, it is broken, considerable mobility of both bones occurs, with crepitus The fore-arm is semi-flexed, the hand held midway between pronation and supination, and the displaced bones form a considerable swelling at the back of the joint, above which is a marked hollow, crossed by the triceps. The lower end of the humerus projects in front, and the artery and the soft parts are displaced forwards. The measurement from the acromion process to the external condyle remains unaltered, but that from the condyle to the styloid process of the radius is distinctly shortened, and the distance between the condyles and the olecranon process is increased.

Dislocation **forwards** of both bones rarely occurs without fracture of the olecranon process, although a few cases of this unusual accident are on record. The displacement is readily detected, the fore-arm being lengthened perhaps to the extent of an inch. The arm is in a condition of flexion, and, indeed, the accident can only take place from falling backwards on the point of the elbow when in this position. The triceps muscle may be considerably torn.

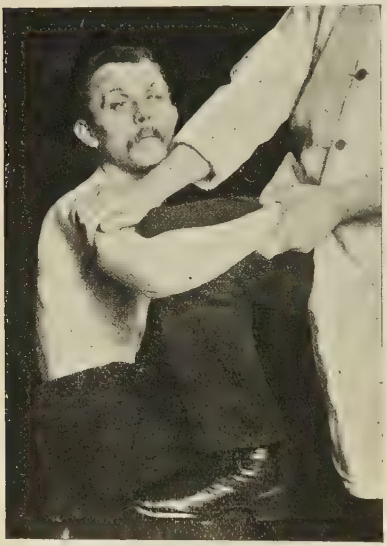


Fig. 299.—Reduction of Backward Dislocation at the Elbow.

Lateral dislocations of the fore-arm are almost always incomplete, and are not very frequent; the bones may be displaced either inwards or outwards, the latter being the more common. They are recognised by a careful examination of the relative position of the bony prominences and by stereoscopic radiography.

2. **Dislocation of the Ulna alone** occurs only in a *backward* direction. It is very rare owing to the position and strength of the orbicular and oblique ligaments and of the interosseous membrane. If, however, the bones of the fore-arm are rotated backwards upon the head of the radius as a fulcrum, and then the fore-arm adducted, this displacement can occur without extensive ligamentous lacerations, which, indeed, have not been noted in any of the cases observed.

In the **Treatment** of the above dislocations, all that is necessary is to unhitch the interlocking bony prominences, so as to allow the bones to return to their normal positions by muscular contraction. This is usually accomplished by the method described by Sir Astley Cooper. The patient being in a sitting position, the surgeon presses backwards, with his knee in the bend of the elbow, against the lower end of the humerus; at the same time he grasps the patient's wrist, and slowly and forcibly bends the fore-arm (Fig. 299).

3. **Dislocation of the Radius alone** may occur either *forwards, backwards*, or *outwards*.

The **forward** dislocation (Fig. 300) is that usually seen, and results from falls on the hand when the fore-arm is in a state of extreme pronation, or from forcible traction upon the hand, or from direct injury applied to the back and outer side of the elbow. The head of the radius rests against the lower end of the humerus in the hollow above the capitellum, and the most characteristic feature consists in the inability of the patient to flex his fore-arm, owing to the bone impinging against the lower end of the humerus. It can be readily detected in this situation, rotating with the movements of the fore-arm, whilst a deep hollow is felt behind, immediately below the external condyle. The fore-arm is somewhat flexed, and midway between pronation and supination; the former act can be satisfactorily accomplished, but supination cannot be carried further than half-way. A marked fulness exists on the anterior aspect of the limb when the arm is extended. Fracture of the upper third of the ulna sometimes accompanies this accident, especially when produced by direct violence. If this luxation is not reduced, great impairment of the mobility of the limb results, flexion beyond an obtuse angle becoming impossible. **Treatment.**—Reduction is accomplished by traction from the wrist, with the fore-arm flexed to a right angle, combined with pressure over the head of the bone. Owing to the fact that the orbicular ligament is ruptured, the deformity is likely to recur, unless the limb is kept completely flexed in order to relax the biceps. Active movements of the limb must be interdicted for three or four weeks. In old-standing cases excision of the head of the bone is desirable.

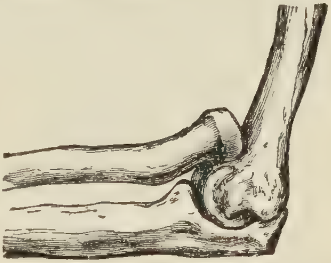


FIG. 300.—DISLOCATION OF THE RADIUS FORWARDS. (PICK.)

Dislocation **backwards** is less common. The head lies behind the external condyle on the outer side of the olecranon, where it can be detected on rotating the limb. The fore-arm is flexed, and the limb pronated. Even if left unreduced, it leads to but little inconvenience.

Dislocation **outwards** is also rare, the head of the bone being displaced to the outer side of the external condyle, where it can be felt, causing considerable impairment of movement. Reduction is accomplished without difficulty, or, if necessary, the head may be excised.

Occasionally a rare form of dislocation is met with in which the ulna passes backwards and the radius forwards, resulting in great deformity.

A very common accident in children under four years of age consists of a **subluxation of the head of the radius downwards** within the orbicular ligament, so that a fold of synovial membrane slips up and becomes nipped between the head and capitellum. It results from forcible traction of the hand, as from pulling up a child roughly after it has fallen, and is a common nursery accident, popularly known as **pulled elbow.** The limb becomes fixed in a position of slight flexion, and with the hand pronated, and the child cries out with the pain; it is readily treated by completely flexing the limb, and subsequently extending and fully supinating it, and leaves no bad results.

It must not be forgotten that here merely the pure dislocations have been described. In actual practice **complications** of a serious nature are frequently present in the shape of fracture of one or both condyles, which add to the difficulty of diagnosis, apart from radiography, and even then the results of treatment may be unsatisfactory. Abundant callus is formed, and fibrous adhesions of such strength are developed, that considerable impairment of function is liable to ensue.

Dislocation of the Wrist is a very uncommon accident, and may occur *forwards* or *backwards*. The lower ends of the radius and ulna project under the skin, and the styloid processes retain their relative positions; it is thereby easily distinguished from a Colles's fracture.

Occasionally the radius, carrying with it the hand, is dislocated from the lower end of the ulna, as a result of forcible pronation, which results in laceration of the inferior radio-ulnar ligaments, and probably of the lowest portion of the interosseous membrane. The triangular fibro-cartilage is in some of these cases loosened, and its mobility may subsequently give rise to a painful weakness of the wrist. The ulna projects backwards, and its reduction is easy; but some laxity of the inferior radio-ulnar joint may persist, unless the bones are kept firmly together by suitable bandaging.

Dislocations of Various Carpal Bones have been described, and radiography has demonstrated that they are by no means uncommon. That which is best known is a displacement of the os magnum backwards. It forms a rounded prominence under the skin in the usual situation of the bone, which becomes more prominent on flexion, and may disappear on extension. As a rule, it is readily reduced, but is very likely to recur. If troublesome, the bone may be excised.

Dislocations of the Metacarpal Bones and Phalanges are not unfrequent, but need no special mention, except in the case of **Dislocation Backwards of the First Phalanx of the Thumb**. The chief interest here lies in the difficulty experienced in reduction, which was formerly attributed to the head slipping between the two portions of the flexor brevis pollicis and being grasped by them, as a button in a button-hole. It has now been shown that there are two much more important factors, viz., the tension of the long flexor tendon, which hitches round the neck (Fig. 301), and the arrangement of the glenoid ligament. This fibro-cartilaginous structure passes between the two heads of insertion of the short flexor, and is thus incorporated between the two sesamoid bones; whilst firmly attached to the base of the phalanx, it is but loosely connected with the head of the metacarpal bone, so that it accompanies the phalanx in its dislocation, and will then be situated immediately behind the head of the metacarpal, so as to prevent any attempts at reduction. **Treatment.**—Traction and manipulation are always attempted in the first instance. The thumb is grasped by a suitable apparatus and hyper-extended to a right angle, thus making the head of the metacarpal project still further through the muscular interspace, and, as it were, enlarging the buttonhole. Still maintaining the traction, the thumb is rapidly flexed into the palm, the metacarpal bone being at the same time pressed inwards. Should this fail, as it often will, a sterilized tenotome should be inserted in the middle line of the thumb behind, immediately above the base of the phalanx, and should be pushed on till it reaches and divides the glenoid fibro-cartilage between the sesamoid bones; this little manœuvre will at once render replacement simple.

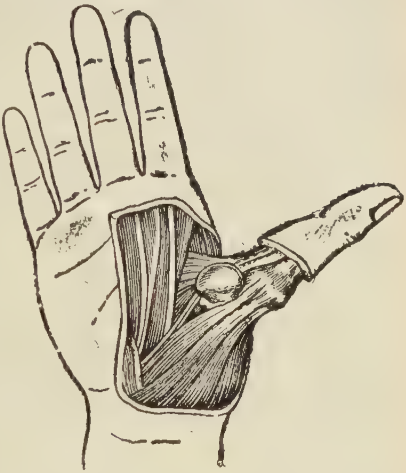


FIG. 301.—DISLOCATION OF THUMB, SHOWING HEAD OF THE METACARPAL BONE PROTRUDING FORWARDS BETWEEN THE HEADS OF THE SHORT FLEXOR MUSCLE. (PICK.)

Dislocation of the Hip, though not very common, is a condition of extreme gravity. The depth of the socket in which the femur rests, and the strength of the muscles and ligaments surrounding the articulation, explain the comparative unfrequency of the accident. It always results from violence applied to the feet or knees, or, if the legs be fixed, to the back. It is rarely met with except in young people or adults, since after the age of forty-five fractures of the neck of the bone are much more likely to occur.

Four chief varieties of dislocation are described, in two of which the head of the bone is displaced posteriorly, and in two anteriorly. The two former are known as the *Dorsal* and the *Sciatic* varieties, in which the head of the bone occupies some situation on the dorsum ilii, determined by the integrity or not of the obturator internus tendon. The two anterior dislocations are known as the *Obturator* or *Thyroid*, and the *Pubic;* in the former the head of the bone is located in the obturator notch, and in the latter upon the pubic ramus. The relative frequency of these dislocations is as follows: About 50 to 55 per cent. of the cases are of the dorsal type, 20 to 25 per cent. sciatic, 10 to 15 per cent. obturator, and 5 to 10 per cent. pubic. In addition to these four varieties, many other slight modifications have been described, which it will be unnecessary further to particularize.

Mechanism.—In considering these dislocations, the relative strength or weakness of the different parts of the capsule and its surrounding structures must be remembered. The weakest part of the capsule is placed below and behind, and it is through a rent in this position that the head of the bone most frequently escapes. In front, the ilio-femoral or Y-shaped ligament of Bigelow is a structure of much strength, on the integrity of which depends the fact whether the displaced head of the bone shall occupy some definite position or be freely moveable. Bigelow, to whom we owe so much in the elucidation of the mechanism of these dislocations, has divided them into two classes—the *regular* and the *irregular*—according to whether this ligament is intact or completely lacerated. Posteriorly, the plicated tendon of the obturator internus is the most important structure, and the position and level of the bone on the dorsum ilii depend in some measure on whether it remains intact or is ruptured. It must also be remembered that the ligamentum teres is relaxed when the thigh is forcibly abducted, and is made tense by adduction.

The limb is usually in a position of *abduction* at the moment of dislocation, the head of the bone escaping through a rent in the lower and back part of the capsule. The type of accident responsible for this is a fall with the legs widely separated, or when the limbs are drawn forcibly apart, as, for instance, when one leg is placed on a boat just moving away from a pier on which the other is fixed. The direction of the violence, or the subsequent manipulations performed by willing but ignorant friends, or the voluntary movements of the individual, determine what form of dislocation will be subsequently produced. If the limb is externally rotated and extended, or the trunk is hyper-extended and the limb remains fixed, the head travels forwards, and either the pubic or obturator variety results. If, however, the leg is inverted and flexed, the head of the bone passes backwards, and either the dorsal or sciatic form is produced. Again, in the posterior dislocations, if the obturator internus tendon remains intact, it may hitch across the front of the neck, and prevent any further upward displacement of the bone, thus giving rise to the so-called sciatic variety, or as Sir Astley Cooper called it, the dorsal below the tendon; but if the tendon is ruptured, or if the head of the bone slips in front of it, there is no obstacle to its upward displacement on the dorsum ilii.

Dislocation may also result when the limb is in a position of *adduction*, a direct dorsal dislocation being thus produced, the head of the bone escaping from the capsule above the tendon of the obturator internus; such an accident is sometimes associated with fracture of the posterior lip of the acetabulum. The type of violence leading to this occurrence is when a heavy weight falls on the back of a person whilst kneeling, or when, the knee being flexed, the body is thrust forwards, so that the limb is forcibly inverted. If, however, the thigh is in a position of extreme flexion, the head may be displaced below the tendon of the obturator internus, and the sciatic variety will then result.

1. **Dorsal Dislocation** (Fig. 302).—The head of the bone lies on the dorsum ilii, a variable distance above and behind the acetabulum, and always above the obturator internus tendon. It may be detected on manipulation of the limb, although in muscular subjects this is difficult. The ligamentum teres is necessarily ruptured, as also the capsule, the rent being situated either below or above the obturator tendon, according to whether the dislocation is due to forcible abduction or adduction. The small external rotator muscles are often lacerated, and perhaps even the glutei and the pectineus. The ilio-femoral ligament usually remains intact. The great sciatic nerve is sometimes compressed or contused. The trochanter is raised above Nélaton's line (p. 532) and approximated to the anterior superior spine; the ilio-tibial band of fascia is therefore relaxed, and there is considerable shortening of the limb, amounting sometimes to 2 or 3 inches. The leg is in a position of flexion, adduction, and inversion, so that the axis of the femur crosses the lower third of the sound thigh. The knee is semi-flexed, and the ball of the great toe rests against the opposite instep; the heel is somewhat raised. A marked hollow is felt in the upper part of Scarpa's triangle, and the main vessels of the limb appear to be unsupported.

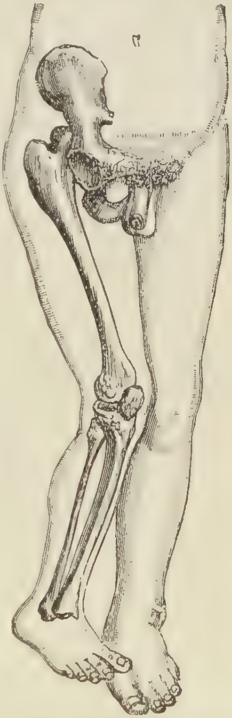


FIG. 302.—DORSAL DISLOCATION OF THE HIP. (TILLMANNS.)

The **Diagnosis** should be easy, the only difficulty being experienced in distinguishing it from an impacted extra-capsular fracture. The character of the accident, the presence of adduction and inversion, the increased breadth of the trochanter in the case of fracture, and the abnormally placed head of the bone in dislocation, are the points to which attention must be directed.

2. **Sciatic Dislocation,** or dorsal below the tendon, is one in which the head of the bone is prevented from travelling upwards to the dorsum ilii by the integrity of the obturator internus tendon. It may occur either from forced abduction of the limb, or from extreme

flexion in the adducted position. The lesions of muscles and ligaments are practically the same as for the dorsal variety. The iliofemoral ligament is uninjured.

The **Signs** resemble those of a dorsal dislocation, but are less marked. There is less shortening, often not more than ½ to 1 inch; the limb is flexed, adducted, and inverted, but the axis of the femur is directed across the opposite knee, and the great toe rests against the ball of the great toe of the opposite side. The head of the bone is often much less distinct, owing to the greater thickness of the glutei muscles at the lower level.

Treatment of the Two Backward Dislocations is effected in much the same way, whether the dorsal or sciatic variety is present. The most usual method is that of *manipulation and rotation*, so accurately worked out by Bigelow. The patient is anæsthetized, preferably on a mattress placed on the floor. The leg is first flexed on the thigh, and the thigh on the abdomen, the position of adduction being still maintained, so that the knee extends beyond the middle line of the body (Fig. 303). This position is maintained for some moments, and then the limb is freely circumducted outwards, and brought rapidly down into a position of extension parallel with the other. By this manœuvre the tense structures in front of the joint are relaxed, and then the head of the bone is made to retrace its course towards the rent in the capsule, and finally directed upwards into the acetabular cavity. These movements are tersely summarized in Bigelow's words—'*Lift up, bend out, roll out.*'

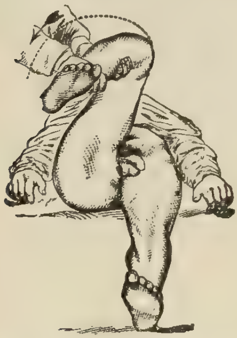


FIG. 303.—REDUCTION OF DORSAL DISLOCATION OF HIP. (BRYANT.)

If this plan does not succeed, the following method of *traction* may be employed. The patient, lying on his back, is firmly fixed by a bandage or towel passed over the pelvis and secured to two or three hooks or staples driven into the floor. The surgeon stands over the patient, whose thigh is flexed to a right angle on the abdomen, as also the knee upon the thigh. The surgeon's arms are passed under the knee sufficiently far to enable him to grasp his own elbows, and the front of the leg is steadied against the operator's perineum. Direct and forcible traction upwards can now be made, and this is often sufficient in itself to lift the head of the bone into the acetabulum. If this is unsuccessful, the movements described above can be energetically repeated in this position. The above plans, combined with the use of an anæsthetic, rarely fail in reducing a backward dislocation of the hip, and hence *extension by means of pulleys* is rarely required. If, however, it is needed, traction should always be made in the direction of the displaced limb, *i.e.*, across the other thigh, counter-extension being obtained by a towel passed between the injured thigh and the perineum. When sufficient force has been applied, the surgeon rotates the limb outwards so as to allow the head of the bone once more to slip into its socket.

3. **Thyroid or Obturator Dislocation** (Fig. 304).—The head of the bone in this case passes downwards through a rent in the lower part of the capsule, and its position is subsequently but little altered, a slight forward and upward movement being alone superadded. The ilio-femoral ligament is untorn, but the pectineus and adductors are very tense, or may even be lacerated; the ligamentum teres is, of course, ruptured. The head lies on the obturator externus muscle, and can be detected in the perineum. The trochanter is less prominent than usual, and, indeed, its normal position may be represented by a depression. The limb is slightly abducted and everted, as well as lengthened, perhaps to the extent of 2 inches, though this is more apparent than real. It is also flexed, owing to the tension of the ilio-psoas muscle, and advanced before the other, with the toes pointing outwards. The adductor longus tendon stands out prominently, and much pain may be experienced from pressure on the obturator nerve. If the patient stands, the body is bent forwards, whilst it is interesting to note that if the dislocation remains unreduced the patient may be able to walk without

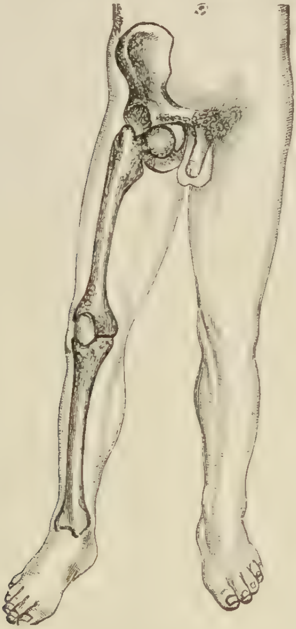


FIG. 304.—DISLOCATION OF THE HIP: OBTURATOR VARIETY. (TILLMANNS.)

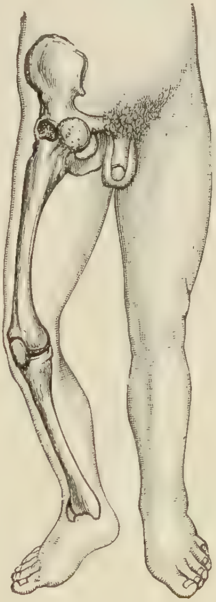


FIG. 305.—DISLOCATION OF THE HIP FORWARDS: PUBIC VARIETY. (TILLMANNS.)

much pain or inconvenience, though in a more or less stooping position.

4. **Pubic Dislocation** (Fig. 305).—In this variety the head of the bone either escapes from the joint below, or may be forced out in front and to the inner side of the ilio-femoral ligament as a result of hyper-extension of the trunk. The head lies on the horizontal ramus of the pubes, just internal to the anterior inferior spinous process of the ilium, where it can be felt rolling under the finger on any movement of the limb. The vessels are pushed inwards, and considerable pain may be felt down the limb from pressure on the anterior crural nerve. The ilio-femoral ligament is untorn, whilst the ligamentum teres and capsular ligament are ruptured; the small external rotator muscles, with the exception of the obturator internus, are usually torn. There is marked flattening of the hip, the trochanter being approximated to the middle line and raised. The limb is shortened to the extent of 1 inch, and there is considerable abduction and eversion, so that the inner aspect of the limb looks forwards. The thigh is slightly flexed to relax the ilio-psoas muscle.

Treatment of the thyroid and pubic dislocations is undertaken along similar lines as for the posterior dislocations. The patient is anæsthetized; the knee is flexed, as also the thigh upon the abdomen, but in a position of abduction; circumduction inwards follows (Fig. 306), and on extension of the limb the head again enters the acetabulum. The thyroid variety may sometimes be reduced by upward and outward traction when the limb has been flexed to a right angle in the abducted position, the unbooted foot being placed against the pelvis to steady it.

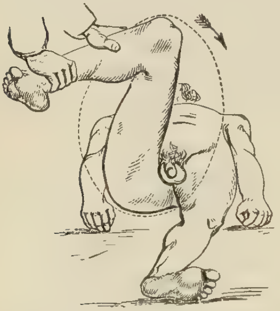


Fig. 306.—Reduction of Anterior Dislocation of the Hip. (Bryant.)

If extension by pulleys is required in the thyroid dislocation, it is made transversely outwards across the upper part of the thigh, counter-extension being obtained by means of a band passed round the abdomen. The limb, at first in a position of abduction, is subsequently adducted forcibly by drawing the ankle inwards, the band by means of which extension is being made acting as a fulcrum to lever the head of the bone into the acetabulum. In the pubic variety traction is made downwards, outwards, and backwards, and the head of the bone drawn into its socket by a towel passed transversely across the limb.

After reduction of any form of dislocation of the hip, the patient should be kept in bed with the legs tied together for about a fortnight, and then passive movement may be commenced, but with considerable caution; voluntary movements should not be undertaken for another week or two.

Should the dislocation recur, it may be due to fracture of the posterior lip of the acetabulum, or to some involuntary movements of the patient, or perhaps to the fact that the displacement has not been fully reduced. Under such circumstances further attempts at replacement should be undertaken, and the limb subsequently kept immobilized for a longer period than usual with a weight-extension and a Liston's splint.

Dislocation of the Patella may occur *outwards, inwards*, or *edgeways*. A dislocation upwards resulting from rupture of the ligamentum patellæ is sometimes described, but it is scarcely to be included in the same category as the others. The displacement may be complete or incomplete; in the former the capsule is always lacerated; in the latter, not necessarily so.

The **outward** variety is much the commonest on account of the obliquity of the limb, and may result from muscular action, especially in people suffering from genu valgum; it also arises from direct violence. In either case it occurs most frequently when the limb is extended, since during flexion the bone is firmly lodged in the intercondyloid notch. When completely displaced, it lies upon the outer surface of the condyle, with its inner margin projecting forwards. In this situation it is easily felt, whilst the knee appears flattened and broader than usual, the intercondyloid notch being plainly distinguishable in the position usually occupied by the patella. It is not unfrequently, however, incomplete, and then the inner half of the articular surface of the patella lies in contact with the cartilaginous surface of the outer condyle, with its outer border projecting forwards. *Reduction* may take place spontaneously, but is usually effected by manipulation. The thigh is flexed on the abdomen, and the knee extended, so as to relax the quadriceps, and then a little pressure on its outer margin causes the bone to slip back into place. In the incomplete form, where one of the borders of the bone is lodged in the intercondyloid notch, reduction is sometimes very difficult, and to effect it an open operation may be required.

The **inward** dislocation is rare, being always due to direct violence. In characters and treatment it is the exact converse of those met with when the bone is displaced outwards.

A dislocation edgeways, or **Vertical Rotation** of the patella, is an interesting condition in which the bone is said to be twisted vertically upon its own axis, and even to have been turned completely round. Incomplete rotation is practically identical with that just described as an incomplete lateral dislocation, whilst the complete rotation of the patella must indeed be a rare accident.

Recurrent dislocation of the patella may be associated with genu valgum, or with laxity of the extensor muscles from paralysis. In the former case it may be cured by correcting the deformity by means of osteotomy of the femur; but sometimes the synovial membrane of the knee-joint on the inner side will require to be braced up by excision of a portion and suture of the margins of the defect. In the paralytic variety, when the extensor muscle is slack, it may suffice to pleat up the rectus or to shorten it by a plastic operation.

Dislocations of the Knee may occur *laterally*, as also *forwards* or *backwards*. When due to disease of the joint, the backward dislocation is commonest; but when arising from traumatic causes, the lateral is the most frequent.

The **lateral** displacements are rarely complete, and are usually associated with a certain amount of rotation; the leg is partially flexed. Reduction is effected without difficulty.

Dislocation of the tibia **forwards** is more common than displacement backwards. It is generally complete, the lower end of the femur projecting into the popliteal space, and compressing the vessels, so that gangrene not unfrequently follows. The upper end of the tibia, carrying with it the patella, lies in front, forming a well-marked swelling with a hollow above it. There is usually considerable shortening of the limb if the articular surfaces overlap.

Dislocation of the tibia **backwards** is a much rarer accident, and is also as a rule complete (forty out of fifty-five cases were complete).* The signs are exceedingly characteristic, the pressure effects upon the popliteal vessels and nerves often resulting in gangrene (ten cases out of fifty-five).

Reduction of either of these conditions is easily accomplished by traction on the limb, whilst the thigh is flexed, combined with manipulation in order to guide the head of the tibia into its normal position. The limb must subsequently be kept at rest on a splint for two or three weeks.

Displacement or Rupture of a Semilunar Cartilage (*syn.*: **Subluxation of the Knee, Internal Derangement of the Knee-Joint**) is a condition frequently met with, resulting from sprains and strains associated with torsion. In any rotary movement of the knee, which is only possible when the limb is flexed, the pressure of the condyles always tends to modify the position of the cartilages, which, moreover, are relaxed and more freely moveable on the upper surface of the tibia in flexion than in extension. Displacement of a cartilage is almost always due to a sudden strain or wrench of a rotary type, *e.g.*, turning quickly round in such games as tennis or football, or slipping off the kerb with the knee bent. The inner cartilage is much more frequently affected than the outer, and the character and extent of the lesion varies much in different cases. Sometimes its anterior or posterior tibial attachment is torn through, thereby permitting considerable lateral mobility (Fig. 307); but more frequently the cartilage is broken across the middle (Fig. 308) or split longitudinally (Fig. 309), thereby detaching a hinged portion from its free border, which slips in or out of position, and not uncommonly gets nipped between the bones, or may even be doubled over. It subsequently becomes inflamed and swollen, and unless properly treated the displacement is likely to be repeated.

The **Symptoms** produced by this accident are a sudden sickening pain of much severity, located in the knee, which becomes partially locked in a position of flexion, with inability to extend it. The patient may be able to 'wriggle' his joint free, or the limb may remain stiff for some hours, or even a day or two, when movement suddenly returns more or less spontaneously, a snap being at the same time felt within the joint. An attack of subacute synovitis usually follows. In other cases the cartilage remains out of place, until reduced by the surgeon, with or without an anæsthetic. If the case is not correctly treated, the displacement is liable to recur, the cartilage constantly slipping in and out, and getting nipped between the bones; as times goes on, this becomes more and more easy, owing to the ligaments of the joint being relaxed from the recurrent attacks of synovitis. In fact, the limb may pass into such a state of chronic weakness as to interfere seriously with the patient's comfort. There is usually a spot of localized pain in the front of the joint, corresponding to the upper surface of the tibia; possibly there may be some amount of lateral mobility of the leg, and movement of the cartilage may be detected on flexing and extending the knee.

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* Sheldon, *Annals of Surgery*, January, 1903.

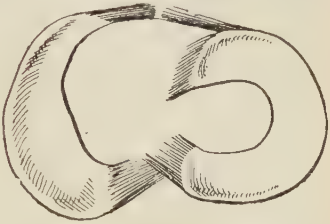
FIG. 307.

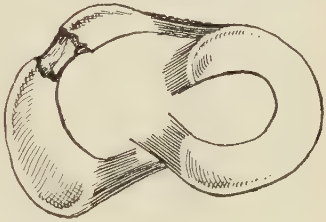
FIG. 308.

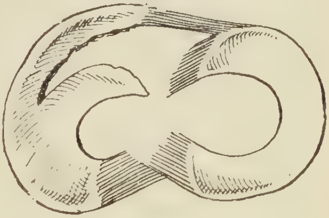
FIG 309.

FIGS. 307, 308, 309.—DIAGRAMS OF VARIOUS TYPES OF INJURY SUSTAINED BY THE INTERNAL SEMILUNAR CARTILAGE.

In Fig. 307 the anterior attachment has been stretched and torn, and the cartilage is consequently loose. In Fig. 308 the cartilage has been torn transversely across, and a weak cicatrix has formed. In Fig. 309 the cartilage is split longitudinally, and it has a loose tag, which causes trouble.

The **Diagnosis** is not always easy, as the symptoms may be simulated by other conditions, such as a loose foreign body in the joint (p. 664), or a fringe of synovial membrane thickened and swollen protruding backwards and getting caught between the bones, or perhaps pushed backwards by enlargement of the bursa beneath the ligamentum patellæ. The definite history of a traumatic onset is an important element in the diagnosis of a torn or loose meniscus. Inflammation of a semilunar cartilage (*meniscitis*) also needs to be considered; it usually results from a heavy fall on the foot or heel, whereby the cartilage is bruised; painful limitation of movement results, and especially pain on standing, or straightening the knee, which is kept semiflexed; there are usually no sudden attacks of painful locking of the joint, but the cartilage is tender, and can perhaps be felt, though it is not moveable.

The **Treatment** in the early stages consists in replacement of the cartilage by manipulation. The limb is fully flexed and then suddenly extended, pressure being applied at the same time in the neighbourhood of the displaced cartilage, which often returns into position with a distinct snap. The limb is subsequently kept at rest on a back-splint, and cooling lotions are applied until the inflammation has subsided; it is then further immobilized for some weeks in removeable plaster of Paris or water-glass, so as to allow the lacerated ligaments to reunite and consolidate. During this period massage is employed, passive movements are permitted, followed by active movements, and movements against resistance, and finally the patient is again allowed to walk.

When the cartilage has become loose and is constantly slipping out of place, immobilization of the limb, with pressure by an elastic knee-clip, or by a knee-truss (Fig. 310), may be useful. Should this not prove satisfactory, operative proceedings must be undertaken.

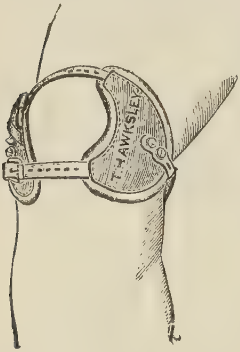

Fig. 310. — Knee-Truss for Dislocated Internal or External Semilunar Cartilages, or for Chronic Dislocations of the Patella.

The knee-joint is opened by a curved incision on the appropriate side of the patella, and the condition of the cartilage ascertained. If of normal shape and merely loose and moveable, it may perhaps be stitched to the periosteum over the head of the tibia, so as to keep it from again slipping between the bones; this is sometimes best accomplished by splitting the cartilage diagonally into two portions, and securing each of these by two or three stitches. If, however, the cartilage is very loose or much torn, it is better to remove it. The joint is carefully closed, and kept quiet for ten days, when massage and suitable exercises are commenced, so as to consolidate and strengthen the divided tissues.

For general considerations concerning intra-articular operations, see p. 629.

Rupture of the Crucial Ligaments is another form of internal derangement, resulting from great violence. The integrity and strength of the joint are much impaired, and abnormal lateral and antero-posterior movements are possible. The only **Treatment** is to open the joint and suture the ligaments.*

Dislocations of the Ankle-joint may occur in the following directions: *outwards*, *inwards*, *backwards*, *forwards*, and *upwards*, this being the order of their frequency. Owing to the fact that the astragalus is wedged like a block into the mortice formed by the lower ends of the tibia and fibula, it is obvious that fractures of these bones are frequently met with as complications.

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* Mayo Robson, *Annals of Surgery*, May, 1903.

The **lateral** dislocations are in reality fracture-dislocations, and have been already described in the chapter on fractures (p. 550).

Although the upper articular surface of the astragalus is broader in front than behind, dislocation of the foot **backwards** is a more common accident than displacement forwards. It results from falls on the feet while running or jumping, or by sudden violence applied to the limb when the foot is fixed. Usually both malleoli are fractured, and the articular surface of the astragalus is thrown behind the lower end of the tibia. The heel projects unduly backwards, and the articular surface of the tibia usually rests upon the neck of the astragalus, the scaphoid, or even the cuneiform bones.

Dislocation **forwards** is very uncommon, and may occur without any associated fracture of the bones of the leg. The foot is apparently lengthened, and the tibia rests upon the posterior part of the upper surface of the os calcis, behind the astragalus, the prominence of the heel and of the tendo Achillis being lost.

The *treatment* of antero-posterior dislocations consists in reduction by traction. The leg is flexed upon the thigh, so as to relax the tendo Achillis, or, if necessary, this structure is divided. The ankle is subsequently commanded by a pair of Cline's side-splints, care being taken to keep the foot at right angles to the leg, and the articular surfaces of the astragalus and tibia exactly in apposition.

A dislocation **upwards** has been described in which the astragalus, together with the foot, is carried up between the tibia and fibula, owing to a rupture of the inferior tibio-fibular ligament and the lower end of the interosseous membrane. The displacement is very marked.

Dislocation of the Astragalus alone is by no means common. It consists in a partial or complete detachment of the bone from all its normal connections, both to the bones of the leg and of the foot, and its displacement from under the tibio-fibular arch. It may travel *backwards* or *forwards* with or without lateral rotation, and be complete or incomplete. It is frequently more or less compound.

Dislocation **forwards** is much the more common variety, and is usually associated with partial rotation, the displacement occurring more frequently outwards than inwards. When complete, the bone is entirely detached from its connections, and lies upon the upper surface of the external cuneiform and cuboid bones, the skin of the dorsum being tightly stretched over it, or even torn.

In the incomplete variety, the head of the astragalus impinges either upon the scaphoid on the inner side, or the cuboid on the outer, whilst the lower end of the tibia rests on the posterior half of the articular surface of the astragalus.

Dislocation **backwards** is almost always complete, and may or may not be associated with rotation of the bone, which can easily be felt between the tendo Achillis and the malleoli.

Treatment.—Reduction is only possible in the incomplete forms of dislocation. The patient is anæsthetized, the knee flexed to relax the muscles or the tendo Achillis divided, and traction upon the foot established, so as to enable the surgeon to apply pressure upon the displaced bone in a suitable direction. In the complete variety reduction is impracticable, owing to the fact that the os calcis is drawn up into contact with the malleolar arch. In such cases manipulation is useless, and excision of the bone is necessary. Comparatively little impairment in the function of the foot results from this operation.

Subastragaloid Dislocation.—By this term is meant a displacement of all the bones of the foot from below the astragalus, which retains its normal position between the malleoli. It is due to some violent strain or wrench of the foot. Displacement may occur either forwards or backwards, but in the great majority of cases it is either *backwards and inwards* or *backwards and outwards*. The luxation is rarely complete as regards the calcaneo-astragaloid joint, but the articular surfaces of the head of the astragalus and scaphoid are completely separated, the former structure lying on the dorsal surface of the latter bone. The foot is greatly deformed, the anterior portion being shortened, the heel projecting, and the toes pointing downwards. The head of the astragalus forms a rounded globular swelling under the tense skin. In a compound dislocation of this nature examined *post-mortem*, the inner edge of the under surface of the astragalus had burst through the skin; the vessels and nerves were torn or stretched, and even when the wound in the skin had been enlarged, reduction was impossible owing to the tendons which were caught around the neck of the astragalus. In such a case removal of the astragalus would have been the only practicable treatment.

In the **inward** displacements, the foot is somewhat inverted, so that the outer malleolus is unduly prominent, and the inner malleolus is lost in a deep depression caused by the lateral displacement of the os calcis; the foot is thus in a position somewhat simulating talipes equino-varus. In the **outward** dislocations the foot is everted, the inner malleolus prominent, and the outer buried, a position of talipes equino-valgus being thus assumed. In both forms the tendo Achillis is curved, with its concavity towards the displacement. *Treatment* consists in reduction by manipulation, which is sometimes readily accomplished, but may be a matter of the greatest difficulty, probably from the tibial tendons becoming hitched around the neck of the astragalus. Section of the tendo Achillis is occasionally needed. In difficult cases excision of the astragalus may be required, and when there is much associated injury to the soft parts amputation.

CHAPTER XXIII.

DISEASES OF JOINTS.

General Considerations.—A careful study of the anatomy and physiology of joints is required in order to appreciate the many problems, mechanical and pathological, which confront the surgeon in the treatment of their diseases. Limitations of space prevent us from discussing these, but we would remind students that the exposed ends of the bones entering into a joint are covered with articular cartilage, and in young people are separated from the shafts by the intervention of epiphyses, which protect the joint in many cases from the spread of disease from the diaphyses, but in some cases are a source of danger in that the junction cartilages are intra-articular. Holding the bones together is a complicated series of ligaments, of varying strength and density, usually inserted into the epiphyses in young people, and arranged so as to resist the various forms of strain to which the particular joint is exposed. Lining the under side of the ligaments, and more or less closely attached to them, is the synovial membrane, a thick, smooth structure which secretes a glairy fluid for lubricating purposes; it extends as far as the margins of the articular cartilages. Where it is not in close proximity to the ligaments, as in the knee-joint, the interspaces are padded with fat, which may occasionally prove a source of trouble. On the inner aspect of the membrane are a number of small villi, which sometimes develop to a considerable size.

Inflammatory affections of joints are of the most diverse character, and are brought about by injury, infection, or general constitutional conditions, such as gout. The trouble may be limited mainly to the synovial membrane, constituting merely a *synovitis*, or may spread to or involve the other articular structures, such as ligaments, cartilages, ends of the bones, etc., thereby constituting an *arthritis*.

Effusion into a joint occurs in most of the various manifestations, the exudate varying with the cause. The phenomena, however, are similar in all the diverse conditions, and it would be well to note them here. *Shoulder :* The curvature of the shoulder is increased, and the deltoid expanded by a fluid swelling beneath it, which is especially noticeable at its anterior border along the bicipital groove, and sometimes posteriorly; in the axilla a painful intumescence may also be felt. These symptoms may be somewhat simulated by inflammation of the multilocular subdeltoid bursa, but the latter condition is recognised by the absence of any axillary swelling, by its not encroaching on the anterior and posterior borders of the deltoid, and by the fact that, although when the patient voluntarily moves his arm pain is produced, yet when the surgeon gently manipulates it, so as to press the head of the bone against the glenoid cavity, there may be none. *Elbow:* The hollows on either side of the olecranon and tendon of the triceps are replaced by soft fluid swellings, the outer of which also extends down to, and masks, the head of the radius; there is usually a little general puffiness in front of the joint. It is readily distinguished from inflammation of the olecranon bursa by the fact that in the latter condition there is a central fluid prominence over the bone, whilst in the former the swellings are placed on either side of and above the bony projection. *Wrist:* There is a general fulness around the joint, most marked on the anterior and posterior aspects, but also noticeable below the styloid processes. The tendons in their sheaths are lifted up back and front, and deep fluctuation may be detected beneath them. It is distinguished from a teno-synovitis by the facts that the swelling is limited more or less to the joint line, and does not extend up and down in the direction of the tendons; there is also no limitation of movement of the fingers, and the characteristic crepitus of teno-synovitis is absent. Effusion into the *Hip-joint* cannot be easily detected by digital examination. There may be a little fulness and tenderness in the gluteal region, or in the upper and outer part of Scarpa's triangle. The most characteristic feature, however, is the position of flexion, abduction, and eversion taken by the limb, whilst limitation of movement is equally marked. The *Knee*, when distended with fluid, presents a rounded outline, in which all the normal hollows, especially those on either side of the patella and ligamentum patellæ, have disappeared. There is also a swelling corresponding to the subcrural pouch, more marked on the inner than the outer side, and extending for 3 or 4 inches above the patella. Fluctuation can be readily detected when one hand is placed above the patella, and the fingers of the other hand compress the tissues on either side of the ligamentum patellæ below, or by alternate pressure on either side of the rectus tendon. When the effusion is considerable, the patella is felt to float, and on pressing it sharply backwards can be made to tap against the intercondyloid notch of the femur (*patellar tap*). A smaller effusion is recognised by pressing the fluid downwards from the subcrural pouch with the knee fully extended, when the patellar tap can usually be demonstrated. Enlargement of the bursa patellæ is recognised by the swelling being central and in front of the patella, so that its outline is obscured. *Ankle:* The hollows between the tendo Achillis and the malleoli are replaced by fluctuating swellings, whilst the dorsal tendons are displaced forwards, and a fluid swelling appears in front of each malleolus. Enlargement of the bursa beneath the tendo Achillis is so obviously confined to the back of the joint that it should never be mistaken for true synovitis of the ankle.

Finally, it must be noted that joints are peculiarly liable to bacterial invasion, especially from without. Any breach of strict aseptic precautions is only too likely to be followed by an infection which will have disastrous results, endangering both the utility of the limb and also the life of the patient. Hence the most minute care must be taken in all **operations which involve the opening of joints.** Prolonged sterilization of the skin must be insisted on when possible, and all needless introduction of fingers into the wound should be avoided. No antiseptics are allowed to enter the joint, as they are always somewhat irritating, and may cause a considerable synovial effusion which becomes a suitable nidus for the development of bacteria, if such happen to be present. At the conclusion of the intra-articular manipulation, the joint must be carefully closed by buried sutures, which involve *seriatim* the synovial membrane, the ligaments, the overlying muscular or aponeurotic structures, and finally the superficial parts; exact co-aptation of each of these structures is necessary if good functional repair is to be obtained, free from weakness. Drainage is not as a rule necessary; but if there has been much bleeding the patient's comfort is increased by introducing a drainage-tube for twenty-four hours. The joint is usually kept at rest for a week or ten days, perhaps on a splint, and then movements are cautiously permitted, at first passive, then active, and finally active against resistance, and all these advisably before the patient strains the joint (if a knee) by bearing upon it the weight of the body. Massage to the surrounding muscles will of course be employed as soon as the wound is securely healed.

Acute Synovitis.

In this affection the inflammation is limited almost entirely to the synovial membrane, the ligaments and other structures of the joint being but little affected.

The **Causes** are local and general. Local conditions include cold and injury; general or constitutional comprise rheumatism, gout, syphilis, and gonorrhœa. It is probable that in all cases apart from trauma there is some mild infection, but it is limited in its action and results.

Pathological Anatomy.—Acute synovitis is characterized by hyperæmia, of the synovial membrane, and exudation of plasma and leucocytes, firstly into the substance of the membrane, causing it to be thickened and spongy, and subsequently into the joint; the endothelium also proliferates, and is shed. In the early stages the effusion consists of synovia, diluted with blood plasma, and often discoloured with blood in traumatic cases, and hence on removal is sometimes spontaneously coagulable; after a time the plasma may coagulate, depositing lymph upon the articular surface, whilst serum remains. This lymph may either be removed by a natural process of absorption when the inflammation comes to an end, or it may organize, so as to form adhesions. In some varieties, especially if repair is not quickly established, a certain amount of peri-synovial inflammation follows, resulting in the ligaments becoming congested, infiltrated, and perhaps somewhat relaxed.

The **Clinical Signs** of acute synovitis consist in the joint becoming painful and distended, whilst if the articulation is superficial, as in the knee, a sense of heat may be imparted to the hand, and the surface may even be red and hyperæmic. The limb is maintained by muscular spasm in that position which gives the most ease—viz., that in which its capacity is the greatest, and this is usually one of slight flexion. If the condition is neglected, the flexion may increase considerably, and the limb become more or less fixed in an undesirable position, whilst the muscles governing the movements of the joint undergo rapid atrophy. The phenomena resulting from effusion into various joints have been already noted (p. 627).

When the acute stage has passed, the joint is usually left in a somewhat weak and relaxed condition, with a little passive effusion, or perhaps some adhesions. The *adhesions* which follow acute synovitis are usually slight in character, if the case has been properly treated; they result from the union of patches of lymph on opposing surfaces of synovial membrane or bone, which become organized into loose fibro-cicatricial tissue, containing a few delicate bloodvessels, and covered by endothelium extending over them from the adjacent serous membrane. The characteristic signs of such a condition are painful limitation of movement in some particular direction, and possibly a little soft crepitus.

The **Treatment** of acute synovitis consists in so immobilizing the joint as to give the patient the greatest amount of ease, whilst, should ankylosis result, the limb is left in as favourable a position as possible for subsequent utility. Thus, the *shoulder* should be bandaged to the side, and the hand kept in a sling; the *elbow* is placed on an internal angular splint, and flexed to a little more than a right angle, whilst the hand is midway between pronation and supination; for the *wrist* all that is needed is to apply a palmar splint to the fore-arm; the *hip* is immobilized by the application either of a Thomas's splint or of a Liston's long splint, or by placing the limb between sandbags and adjusting an extension apparatus; the *knee* is put on a back-splint, perhaps slightly flexed; whilst the *ankle* is best kept at rest by applying what is known as a Roughton's splint, *i.e.*, an external splint with a foot-piece. Necessarily, in all severe cases of acute synovitis the patient should be confined to bed and the limb elevated. In the early stages cold should be applied to the joint by means of evaporating lotion, an icebag or Leiter's tubes, but this is not advisable in old people. In the later stages fomentations give greater relief, whilst the application of a few leeches may also be beneficial. When the distension is considerable, removal of some of the fluid by a carefully purified aspirator, or trocar and cannula, may diminish pain and hasten recovery. Such fluid should always be examined bacteriologically, and if organisms are found a vaccine should be prepared. In not a few cases of acute synovitis the induction of passive hyperæmia by the application of an elastic bandage will give relief and hasten repair.

In the subacute stage, when the joint is weak and relaxed, massage or friction with stimulating liniments should be employed, whilst in the later stages elastic pressure is often of the greatest value. If the case has been neglected and the limb has assumed a vicious position, the patient should be anæsthetized and the deformity forcibly corrected; or gradual extension is made by means of a weight and pulley, until the correct position is attained.

If adhesions are present, they should be carefully broken down under chloroform; the limb is subsequently kept at rest for a few days upon a splint, whilst passive movements and massage are afterwards adopted. In bad cases it may be desirable not to do too much at a time, as a good deal of inflammatory reaction is thereby lighted up; the manipulation may be repeated more than once with a few days' interval.

Chronic Synovitis.

This affection follows an acute attack, or may be lighted up by some injury or condition insufficient to determine a more violent form of inflammation. The synovial membrane becomes thick and infiltrated, whilst the effusion is sometimes relatively less than in the acute form, sometimes excessive.

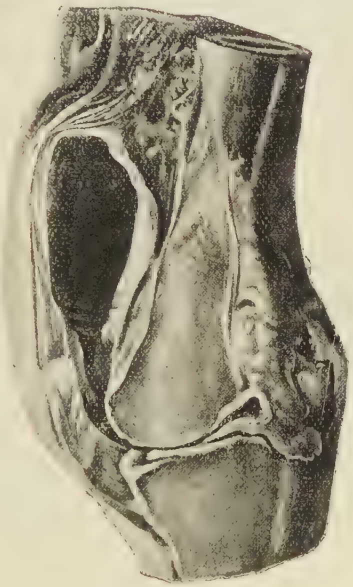

FIG. 311.—CHRONIC SEROUS SYNOVITIS OF KNEE, WITH DISTENSION OF THE SUBCRUREAL POUCH. (FROM COLLEGE OF SURGEONS' MUSEUM.)

Three varieties have been described: (*a*) **Chronic Serous Synovitis** (Fig. 311) is a condition in which effusion is the most prominent factor. It results from many causes, which throw strain upon the joint, or is sometimes inexplicable. It is not unfrequently associated with some condition such as a loose cartilage, osteo-arthritis, etc., and in its most aggravated form constitutes a condition of *hydrarthrosis* or *hydrops* (p. 633). It is not unfrequently seen affecting the knees after rising from a prolonged stay in bed. The fluid is often clear and limpid, and the changes in the structure of the membrane are but slight. The pain is usually not severe, being replaced by a sense of uselessness and weakness. It is interesting to note that, in cases where the effusion is well marked, the bursæ communicating with the joint frequently become distended; they are prevented from participating in the acute forms of inflammation by the fact that the apertures of communication with the interior of the joint are narrow and slit-like, and thus readily become occluded by the swelling of the membrane.

(*b*) **Chronic Synovitis with Thickening of the Synovial Membrane** is always a suspicious condition, as it may be a precursor of tuberculous disease, if it lasts, or an outcome of a syphilitic infection. There is but little effusion, and the membrane may even be palpable. Crepitus is sometimes met with in this condition, possibly from a roughening of the articular surfaces on which lymph has been deposited, or between which fibrous adhesions have formed.

(*c*) **Chronic Papillary Synovitis.**—Occasionally the synovial fringes and the villi of the synovial membrane become hypertrophied, giving rise to a condition somewhat similar to that described under osteo-arthritis (p. 654). The overgrown villi usually spring from the reflections of the synovial membrane close to the bone, and may be loaded with fat, constituting a condition known as 'Lipoma arborescens.' In the knee-joint the fringes may be felt rolling under the fingers, and painful symptoms may be caused by the loose ends being caught and nipped between the bones.

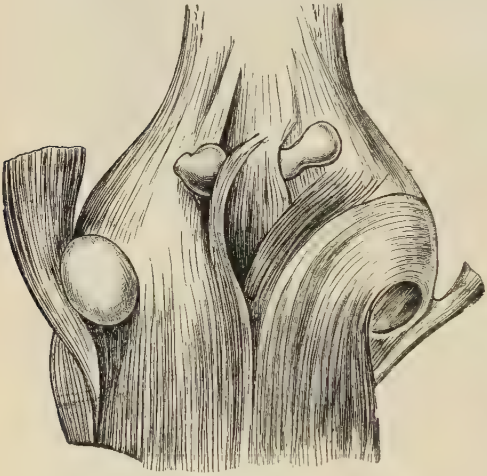

FIG. 312.—BAKER'S CYSTS FROM BACK OF KNEE. (HOWARD MARSH.)

Treatment varies somewhat in the different varieties, but in all commences by keeping the joint at rest in a suitable position, and applying counter-irritation and pressure; Scott's dressing and blisters are especially useful in this affection. At a somewhat later stage Bier's hyperæmia may be helpful, or elastic pressure by a Martin's bandage over the affected joint may be employed, together with friction with stimulating liniments, or even hot-air baths. When effusion is marked and resists these methods of treatment, removal of some of the fluid by aspiration and subsequent compression may do good; but if the effusion re-appears, the best procedure consists in opening the joint, washing it out with sterile saline solution, and draining it for a few days.

In the chronic fibroid form iodide of potassium, or iodolysin* may be useful in addition to the above-mentioned methods, but as a rule one has to rely on prolonged massage, radiant-heat baths, the introduction of iodine by ionic medication, or spa treatment.

Should enlarged villi be present and give rise to trouble, the joint should be opened, and if they are limited in their distribution they may be clipped away, or the synovial membrane from which they grow dissected out. When very extensive, so that removal would involve total excision of the synovial membrane and consequent stiffness, it may be wise to wash out and drain, in the hope that they may become fixed, before undertaking complete extirpation of the membrane.

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* *Iodolysin* is a 5 per cent. solution of the ethyl-iodide of thiosinamin (p 263); 20 to 60 minims may be given by the mouth three times a day.

Hydrarthrosis (Hydrops Articuli) is the term applied to any condition of a chronic nature in which the joint is much distended with fluid. It may arise from at least five different affections: (*a*) Chronic serous synovitis; (*b*) in osteo-arthritis, a very common cause; (*c*) in Charcot's disease; (*d*) in secondary syphilitic synovitis; and (*e*) occasionally in tuberculous disease. It must be remembered that it is but a symptom, and not a disease *sui generis*, and treatment necessarily varies with the cause.

Baker's Cysts.—This condition, first described by the late Mr. Morrant Baker, consists in a hernial protrusion of the synovial membrane of a joint through an aperture in its fibrous capsule (Fig. 312). It is usually due to some chronic affection of the articulation, especially osteo-arthritis or tuberculous disease, whereby the intra-articular pressure is increased, and not uncommonly several such sacs are connected with the same joint. They vary much in size, contain synovial fluid, and, though at first communicating with the joint cavity, have a tendency to travel away from it, burrowing along muscular and fascial planes, and coming, perhaps, to the surface at a distance from their origin, the aperture of communication with the joint having in some instances been shut off. If causing no troublesome symptoms, there is no necessity to interfere; but if they become inconvenient or painful, it is best to dissect them out, closing where necessary by ligature or suture the narrow neck which leads into the joint. Of course, the strictest asepsis must be maintained in all such proceedings, and the causative affection must not be forgotten.

Acute Arthritis.

Causation.—Acute arthritis is nearly always due to infection of the joint cavity with pyogenic bacteria, which reach it either from within or without the body. (i.) It may be due to the entrance of cocci through a punctured or valvular *wound* of the joint, or during operations. The micro-organisms most commonly present are the *Pneumococcus* and the *Streptococcus pyogenes*, but staphylococci and other pathogenic organisms have also been found. (ii.) It may arise in a manner exactly analogous to that in which acute infective osteomyelitis is produced, viz., by *auto-infection.* A slight injury (*e.g.*, a sprain or strain occurring in a weakly child, convalescent from measles or scarlet fever) may result in this affection, which is then commonly due to the pneumococcus. (iii.) It may be produced by the lodgment of a pyæmic *embolus*, and in a similar way it not unfrequently follows as a sequela of fevers, such as enteric or pneumonia, by direct transmission of some infective material. (iv.) It is sometimes met with as a result of *gonorrhœa*, and may then run its course with or without suppuration. (v.) It may be lighted up as a result of the *extension* of inflammation from the end of a neighbouring bone, or from the bursting of a subcutaneous or bursal abscess into the joint. Acute arthritis of the hip-joint is sometimes due to the former of these conditions, being consecutive to an acute infective osteo-myelitis of the upper end of the femur. (vi.) It is occasionally observed as a result of *rheumatism*, the inflammation running a very acute course, and leading to disorganization of the joint, though without suppuration. Such attacks are undoubtedly bacterial in origin.

Course of the Case.—In the early stages acute arthritis manifests itself as a hyperacute synovitis, combined with severe pain and fever. The pain is often so intense that the patient cannot bear the part to be touched or the bed shaken, and indeed the slightest jar of the limb is so exquisitely painful that the patient may scream with agony. The joint itself is distended with a turbid effusion, which rapidly becomes purulent, and the tissues around are hyperæmic and œdematous. The patient naturally places himself in that position in which the limb obtains the greatest ease, and therefore usually semiflexes the joint and fixes it by muscular contraction.

As the disease progresses, pus is formed within the capsule, but in time bursts through it, and either travels directly to the surface, or burrows deeply into the substance of the limb, and spreads along the muscular planes; thus, in the knee an enormous abscess may collect beneath the vasti muscles, stripping them from the bone for a considerable distance. The pain increases whilst the abscesses are forming, and becomes especially distressing at night, the patient being often waked by a painful start just as he has fallen asleep. This condition usually indicates that the articular cartilages are becoming affected, and is explained by the fact that just as the patient loses consciousness, the muscles which fix the joint are relaxed, and allow the inflamed surfaces to shift their position slightly, exciting severe pain and a sudden spasmodic contraction of the muscles. Gradually the deformity becomes more and more obvious, whilst the infiltration and relaxation of the ligaments sometimes allow of abnormal movements—*e.g.*, of lateral mobility in the knee-joint; the ends of the bones become carious, and absolute displacement or dislocation may follow. Sinuses may open in all directions, and the patient suffer from recurrent rigors, caused by toxæmia or the onset of pyæmia. The constitutional effects are always severe, consisting of high fever, and rapid exhaustion from the pain, sleeplessness, and absorption of toxins.

The *terminations* of this affection are as follow: (*a*) Recovery, rarely with a moveable joint, and then only after active interference; in most cases ankylosis in a good or bad position, according to the treatment, is the best result that can be expected. (*b*) During the acute stage the patient may die of pyæmia, or acute toxæmia and exhaustion. (*c*) If he survive the acute stage, chronic suppuration may ensue, and symptoms of hectic and amyloid degeneration of the viscera may supervene. In such cases sinuses leading down to carious bones exist, and, unless efficient measures are taken to obtain asepsis, or to remove the diseased structures, perhaps by amputation, the patient is likely to die from exhaustion or chronic toxæmia.

Pathological Anatomy.—The *synovial membrane*, at first merely infiltrated and hyperæmic, soon becomes converted into granulation tissue, exuding an abundance of pus. The *ligaments* in turn are sodden and relaxed by the presence of a plastic exudation between the fibres, rendering them soft and œdematous, so that the tonic contraction of the muscles easily stretches them and brings about displacement. The *articular cartilages* are disintegrated and destroyed in various ways according to the acuteness of the inflammation and the amount of pressure to which they are exposed. In acute cases they early lose their normal bluish-white appearance, and become opaque and slightly yellow. The central parts, which are exposed to pressure between the ends of the bones, soon disappear, whilst the peripheral portions are eroded by the overgrown granulation tissue developing from the synovial membrane. When once the cartilage has been perforated at any one spot, the suppurative inflammation spreads along its under surface, stripping it from the bone, and thus inducing necrosis, as a result of which isolated portions of dead cartilage may be found lying in the joint. The *inter-articular cartilages* are affected in a very similar manner, and quickly disappear. The *ends of the bone* pass into a condition of acute osteitis, resulting in the transformation of the medulla into granulation tissue, absorption of the bony cancelli with or without suppuration, and sometimes necrosis of small portions of the cancellous tissue (*caries necrotica*). The veins within the cancelli become thrombosed, and hence pyæmia may result. The *periosteum* covering the ends of the bones is also inflamed and hyperæmic, in consequence of which spiculated or stalactitiform osteophytes are produced (Fig. 313). The *muscles* in the neighbourhood of the joint undergo rapid atrophy and fatty degeneration.

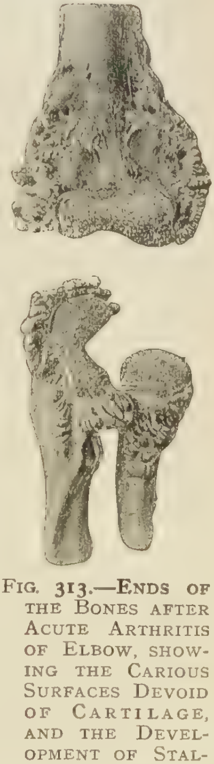

FIG. 313.—ENDS OF THE BONES AFTER ACUTE ARTHRITIS OF ELBOW, SHOWING THE CARIOUS SURFACES DEVOID OF CARTILAGE, AND THE DEVELOPMENT OF STALACTITIFORM OSTEOPHYTES. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

Treatment.—In the early stages the limb must be elevated, absolutely immobilized, and put into such a position that, if ankylosis subsequently obtains, it may be of some use to the patient. Weight extension is usually desirable in order to keep the inflamed articular ends from rubbing; but as light a weight as possible must be used, or the inflamed and softened ligaments may be stretched. Bier's treatment by induced hyperæmia is sometimes of the greatest value in checking the inflammation and relieving pain, which may also be helped by applying fomentations or an icebag. Increasing effusion, especially if suppuration is probable, necessitates an incision into the joint, and the demonstration of the existence of pus indicates the free opening of the joint in as many situations as may be necessary to ensure perfect drainage. The cavity is frequently washed out with some sterile or mild antiseptic solution, and to assist this the openings are made for choice on opposite sides of the joint. A vaccine is, of course, grown from the pus as quickly as possible and administered. It may be wise to discontinue the use of the elastic bandage during the stage of free suppuration, but as soon as it is checked the hyperæmic treatment may be continued. The fixation of the limb is carefully maintained, and the general health attended to. Irrigation should be continued until all signs of inflammation, pain, heat, and startings of the limb have passed away. Should this not occur, it may be desirable to lay the joint even more freely open, and to maintain continuous irrigation with salt solution, to which peroxide of hydrogen has been added. Under such a régime it is sometimes possible to obtain a moveable joint, but more frequently ankylosis must be expected. Excision may be required in order to secure effective drainage in some joints, such as the shoulder; to prevent or remedy faulty ankylosis, or to place the limb in a good position: it is also undertaken in some cases of chronic suppuration, with caries of the ends of the bones or displacement, but, as a rule, not until all acute symptoms have passed away. If the patient is suffering from severe toxæmic or pyæmic symptoms threatening life, amputation may be required, as also for exhaustion from long-standing suppuration and hectic fever.

Acute Arthritis of Special Joints.

In the **Shoulder,** infection sometimes occurs through the axilla where the capsule is weak and easily invaded by organisms, as after an axillary cellulitis; more frequently it follows a penetrating injury. Severe pain is caused by any movement of the arm affecting the joint, and if abscesses form, they will come to the surface in front of or behind the deltoid, or in the axilla. It may suffice to open the articulation anteriorly, and flush it out, but, if possible, a counter-opening should be made behind by cutting down on a pair of dressing-forceps pushed backwards through the capsule. In many instances the patient's condition will not improve until the head of the bone has been excised. The subsequent results as regards movement and power of the arm are, on the whole, very satisfactory.

In the **Elbow,** there are no points requiring special mention as to clinical history or results, although it must be remembered that the superior radio-ulnar articulation is necessarily involved, and hence the power of pronation and supination of the hand is threatened. As to treatment, incisions should be made on either side of the olecranon, the ulnar nerve being avoided. The limb is then placed on a rectangular splint, and with the hand midway between pronation and supination; of course, the patient is kept in bed, with the arm raised on a pillow. In an adult excision may be undertaken as soon as the acute stage has passed, in order to obtain a moveable elbow; but in children, where the growth is incomplete, it is better to allow ankylosis to occur, and excise, if need be, at a later date.

The **Wrist** may be infected secondarily to septic conditions following operations on ganglia in the neighbourhood or through direct injury. The essential treatment consists in free incisions parallel with the tendons, and avoiding the sheaths. Ankylosis usually results, and excision is not resorted to except when the disease has become very chronic, with extensive caries of the carpus.

Acute arthritis of the **Hip-joint** is usually a sequela of acute infective osteo-myelitis attacking the upper end of the shaft of the femur, and involving the joint, owing to the epiphyseal cartilage being intracapsular; it also results from pyæmia, and rarely from penetrating injuries. The symptoms are similar to those of the first stage of ordinary tuberculous disease (p. 670), but much more acute. There is high fever, together with intense pain, marked flexion and eversion of the limb, early suppuration, and rapid disorganization if not properly treated; indeed, where nothing is done, and the patient lives long enough, the head of the bone may be entirely absorbed, or is detached, and remains as a sequestrum in the disorganized articular cavity. As soon as the capsule gives way, the pus may come to the surface in any of the usual localities for hip-joint abscesses. In treating these cases, the joint should be freely laid open in the situation which appears most favourable. The anterior incision is more suitable for the early, and the posterior for the later, stages, when the head of the bone is either dislocated, or remains *in situ* and separated from the shaft. A double opening may sometimes be utilized with advantage.

The **Knee-joint** is more frequently involved by this disease than any other, and is usually infected from without. The symptoms are exceedingly typical: the pain is very acute, and the joint hot and distended to its utmost capacity, the limb lying semiflexed and on its outer side. Left to itself, the capsule gives way, and suppuration rapidly extends upwards beneath the vasti, giving rise to large abscesses, which ultimately find their way to the surface. The deformity gradually increases, until in the worst forms the tibia slips behind the condyles of the femur, the leg is flexed to a right angle and rotated outwards, and if the limb has long rested on its outer side, considerable lateral displacement may also occur. Early and efficient treatment will usually prevent such a disaster. The joint should be freely incised on each side of the patella, so as to open up the subcrural pouch, and the whole articular cavity well washed out. In some cases a counter-opening may be made with advantage and a drainage-tube inserted, by passing a pair of sinus forceps through the outer portion of the posterior ligament of Winslow, and cutting down on it to the inner side of the biceps tendon and clear of the external popliteal nerve. By this means more efficient drainage of the articular cavity is obtained.

When the **Ankle-joint** is involved, amputation has often to be resorted to, in consequence of the difficulty of securing good drainage, although excision of the astragalus will sometimes cut short the disease and lead to a good result.

Special Forms of Synovitis and Arthritis.

Rheumatic Synovitis is met with in the course of acute rheumatism, or as a chronic affection from the commencement. In the former one joint after another is involved; complete resolution usually follows, but there may be some thickening of ligaments and consequent impairment of mobility. If the disease is limited to one joint, absolute disorganization, though without suppuration, may ensue (acute rheumatic arthritis). There can now be little question that this disease is of bacterial origin and due to a diplococcus (Poynton, Paine).

The chronic variety is characterized by swelling of the joints, due partly to effusion, partly to thickening of the synovial membrane, and of the capsular and other ligaments. If neglected, it may produce fixity of the joint, due mainly to ligamentous changes, but also resulting from the development of intra-articular adhesions; but there is never any lipping of the cartilages or new formation of bone, as in osteo-arthritis. Not unfrequently other evidences of rheumatism may be present, such as chorea, erythema, etc., whilst rheumatic nodules* (*i.e.*, new growths of fibrous tissue beneath the skin, perhaps attaining the size of a walnut, but more often much smaller) may also develop.

The **Treatment** of the acute form is medical rather than surgical, and general rather than local. The affected joints must be kept at rest in good position, and wrapped in warm cotton-wool, or, perhaps better, soda fomentations may be applied. Should the inflammation resist such measures, it is quite justifiable to open and wash out the joint, which is found to be occupied by a greenish, semi-puriform effusion.

In the more chronic forms anti-rheumatic drugs have less power, and more attention must be paid to diet. Butcher's meat, sweets, and rich dishes should be avoided, and as far as possible a 'white diet' obtained. Alkaline mineral waters are valuable, and a visit to a suitable home or Continental spa may be desirable. Locally, massage and stimulating embrocations do good, but in bad cases counter-irritation by repeated blisters, or even by applying the actual cautery, may be required. Malposition should be corrected under an anæsthetic or by weight extension. Localized or general hot-air baths do good in most cases, as also diathermy (p. 49) and ionic medication (p. 54) with iodine.

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* Dr. Bannatyne's opinion as to the diagnostic value of fibrous or bony subcutaneous nodules connected with articular lesions is as follows: 'Muscular swellings are most often due to rheumatism, small subcutaneous nodules also to rheumatism, larger ones to rheumatoid arthritis, bursal enlargements to chronic gout, rheumatoid arthritis, or rheumatism, and bony nodes (of the Heberden type) to chronic gout or chronic rheumatoid arthritis.'

Gouty Arthritis is characterized by certain well-marked features. It often attacks the metatarso-phalangeal articulation of the great toe (podagra), or the metacarpo-phalangeal joint of the thumb (cheiragra). Its onset is usually sudden, and it frequently commences in the middle of the night. The tissues around the joint become swollen, red, shiny, and œdematous, whilst the superficial veins are prominent. The attack is exceedingly painful, and the skin exquisitely tender. These symptoms pass off in the course of a few days, leaving the articulation swollen and sensitive.

Even a single attack results in a slight deposit of bi-urate of soda in acicular crystals in the matrix of the articular cartilage close to the surface; but when the joint has been several times inflamed, the whole thickness of the cartilage may be invaded by this chalky deposit, whilst the ligaments and ends of the bones are also infiltrated. In the smaller joints it may increase to such an extent as to form well-marked swellings, or 'tophi,' similar in character to those so commonly seen in the external ear; the skin sometimes gives way over them, and a chalky discharge results. In some cases the cartilages are eroded, and eburnation of the exposed bone may follow, as in osteo-arthritis. The *treatment* of acute gout consists in fomenting the parts or applying glycerine of belladonna, whilst colchicum, citrate of lithia, and alkaline purgatives are administered. In the more chronic forms iodides may be given, and the diet and drink are carefully regulated. Probably some form of hydro-therapeutic treatment will be required, and if the patient cannot go to a suitable spa much may be done at home by getting him to drink a large cup of hot water an hour before each meal.

Pyæmic Synovitis is due to embolic infection from some suppurating focus. The joint becomes rapidly distended with pus, and often without pain. If the joint is promptly opened, washed out and drained, its disorganization may be in many cases prevented (*vide* Pyæmia, p. 97); otherwise destructive changes will quickly follow.

Typhoid Disease of Joints.—1. A *simple synovitis* occurs in one or more joints, with but slight effusion and little inflammatory disturbance. It is somewhat resistant to treatment, and hence may cause limitation of movement. Possibly it is due to the action of toxins rather than of the living organism. 2. The *true typhoid arthritis*, due to the *B. typhosus*, is characterized by a marked inflammatory effusion into one or more joints, and is liable to end in spontaneous dislocation, especially in the hip-joint. Suppuration, however, is rare, and the prognosis favourable, provided the limb is kept in a good position. The presence of a large effusion indicates aspiration. 3. A *mixed pyogenic* and *typhoid* infection results in active suppuration within the joints, the *B. typhosus* playing quite a subsidiary part. 4. A *pure pyogenic* infection. In these latter two varieties the ordinary symptoms of acute suppurative arthritis occur, and the treatment for that affection must be instituted.

Pneumococcal Arthritis.—In the course of an acute pneumonia the pneumococcus is occasionally disseminated through the body, and is then very likely to attack a joint which has been already damaged, giving rise to a suppurative arthritis with an effusion of thick creamy pus, or sometimes to a milder form of synovitis. Males are more often affected than females, and the upper rather than the lower extremity. Occasionally more than one joint is involved, and, with the exception of the hip, the larger joints are attacked rather than the smaller. There are no special peculiarities in the disease, but since it is merely part of a general infection, a high mortality is associated with it. Suppuration usually occurs, and its onset is always an indication for incising, washing out, and draining the joint.

It may also occur primarily and apart from any other obvious pneumococcal lesion. The symptoms are then those of a subacute arthritis with effusion, which may be so resistant to treatment as to require arthrotomy. Some limitation of movement is likely to follow.

Gonorrhœal Disease of Joints is always due to infection with the gonococcus, transmitted by the blood from the primary focus of mischief. It is sometimes associated with pyogenic organisms, and then the prognosis is decidedly worse. In the later stages the pus or serum from the joint is sometimes found to be sterile, the gonococci having died after causing the inflammation. Such an occurrence is always suggestive, as sterile pus is rarely found in an acute abscess due to ordinary pyococci. Whilst usually seen in connection with gonorrhœal urethritis in males, it has been known to follow ophthalmia neonatorum, and has been lighted up by passing a full-sized bougie on a patient with gleet. It generally commences after the third week of the gonorrhœal attack, when the discharge is becoming subacute, but may sometimes appear at a much later period. It may involve one or many joints, the knee, ankle, and wrist being most frequently affected, and perhaps on both sides of the body. Many distinct types of trouble manifest themselves, and they are not unfrequently combined. In one, the synovial membrane is mainly affected, and the effusion is chiefly intra-articular, so that the condition closely resembles an ordinary attack of acute traumatic synovitis, except that it is more severe, more painful, and more persistent.

Occasionally a synovial effusion occurs with but little reaction, and then the gonorrhœal origin is likely to be overlooked. A more frequent form is that in which the peri-articular structures bear the brunt of the mischief; and there is at first but little effusion *in* the joint, but much around it, the parts even becoming œdematous and reddened; the ligaments are infiltrated and softened, so that displacement readily occurs; surrounding muscles atrophy rapidly; the patient suffers from severe pain and fever, so that he becomes thin and worn. In the worst cases the intra-articular effusion increases, and is sero-purulent, yellowish-green in colour, and contains flakes of lymph; sometimes it becomes frankly purulent. All the forms are very chronic and resistant to treatment, and hence ankylosis, with or without disorganization, is very liable to follow. **Treatment** is not very satisfactory. The urethral discharge must be arrested as soon as possible, whilst the affected joints are kept at rest; moderate pressure and counter-irritation, as by Scott's dressing, are useful appliances, but Bier's treatment is perhaps of more value, or in the more chronic stages ionic medication with iodine preparations or hot-air baths. Iodide of potassium, mercury, and quinine may be administered internally. Should the local phenomena be at all severe, the joint must be opened and irrigated, and if undertaken sufficiently early, ankylosis may be prevented. Anti-streptococcic, and even anti-diphtheritic, serum, given *per rectum*, has proved of value in some of these cases, probably by increasing the general resisting power of the body. In most cases a gonococcal vaccine (p. 146) may be employed with advantage, even as an intra-articular injection.

Tuberculous Disease of Joints.

Tuberculous Arthritis (*Syn.:* **Pulpy Degeneration of the Synovial Membrane, White Swelling,** etc.) may commence either in the synovial membrane or in the articular end of the adjacent bone (tuberculous epiphysitis, p. 575); or it may spread to the synovial membrane from the periosteum, as a result of a tuberculous periostitis, or from a neighbouring bursa. In children the disease commences most frequently in the epiphyses, whilst in adults it may start either in membrane or bone with about equal frequency, but considerable variation occurs according to the particular joint affected.

The **Causes** may be summed up as follows: The individual is predisposed to the development of tuberculous disease, often as the result of an inherited tendency; the general health of the patient may also be at fault. Some slight injury, of which but little notice is taken, may lead to the actual deposit of the *B. tuberculosis*, which has probably been lying latent in the bronchial or mesenteric glands, or is present in an active state in the lungs. Severe articular lesions, such as dislocations, are less likely to induce tuberculous disease, partly because their gravity demands efficient treatment, partly because the activity of the reparative process is capable of dealing with the organisms, even if they are brought to the spot.

Pathological Anatomy.—The *synovial membrane* becomes thickened, pulpy, and œdematous, and in the early stages is found to be studded with small gelatinous nodules, about the size of a pin's head, situated immediately beneath the serous lining; later on, these may amalgamate into caseous masses, which burst and discharge into the joint, leaving ulcerated surfaces. Occasionally these masses are of considerable size; more often they are only small. Finally, the synovial membrane is changed into a so-called pyogenic membrane, consisting of granulation tissue similar to that lining the cavity of a chronic abscess, and more or less closely attached to the surrounding structures, which are transformed into œdematous fibro-cicatricial tissue, whilst the superficial parts undergo fatty or necrotic changes. Fringes of the synovial membrane, swollen and succulent, spread over the margins of the *articular cartilage*, and as they increase in size become adherent to it, just as, according to Billroth's classical description, ivy creeps along a wall. On lifting the edges of these fringes, the underlying cartilage is found hollowed out and eroded. As soon as the whole thickness is destroyed at any one spot, the cancellous tissue at the *end of the bone* becomes invaded by the tuberculous disease, and the granulations spread along under the cartilage, cutting it off from its nutritive supply, and thus large flakes of necrosed cartilage may be shelled off (Fig. 314). As a result of the hyperæmic condition of the end of the bone, especially when pyogenic infection is superadded, a new formation of subperiosteal osteophytes, stalactitiform in character, sometimes takes place, but not to such an extent as in a true pyococcal arthritis. Occasionally the periosteum itself is involved in the tuberculous process, and the disease may then extend some distance from the joint. The joint itself usually contains but little fluid, being fully occupied by the swollen synovial membrane; but occasionally in the early stages there is much effusion, constituting a condition known as *tuberculous hydrops*, and in it there may be a considerable amount of fibrin, which is moulded by the movements of the joint into the so-called melon-seed bodies. The chief cytological element in the effusion is the lymphocyte.

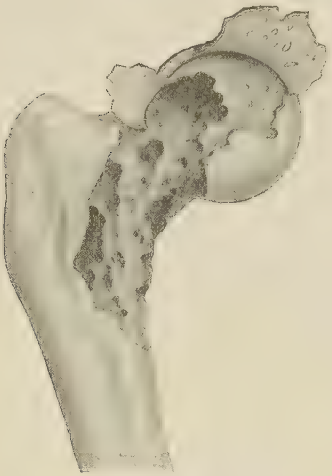

FIG. 314.—TUBERCULOUS DISEASE OF HEAD AND NECK OF THE FEMUR.

The disease evidently started on the under side of the neck, which has been eroded, and spread into the head; the articular cartilage is loose, and necrotic fragments of it have been stripped up off the bone.

The peri-synovial tissues are frequently affected in these cases, especially where there is much loose fatty tissue, as around the knee. The parts are infiltrated and gelatinous, and muscles and tendons are incorporated in the swelling and modified similarly in texture. This change constitutes a large element in what is known as the *white swelling* of a joint.

When the disease originates in the bone in adults, the tissue directly contiguous to the articular cartilage is often that primarily attacked; but in children it more frequently starts in connection with the epiphyseal cartilage. The joint is usually infected by extension of the disease through the articular cartilage; but when the synovial membrane extends along the bone beyond the cartilage, as in the hip-joint, it may become involved without any cartilaginous lesion. In the early stages a simple synovial effusion may occur, and should the osseous trouble quiet down and be cured, this may be absorbed, and merely a few adhesions be left. More frequently, however, infection follows, and the type of trouble varies. Sometimes a tuberculous abscess of the bone or surrounding parts bursts into a joint; acute symptoms supervene, but gradually quiet down, and the usual chronic phenomena subsequently develop. More commonly the infection is due to the gradual erosion of the cartilage towards its periphery, and the onset of the articular symptoms is then of a chronic type.

At any period of the disease a natural cure may supervene, and is characterized by the absorption of the tuberculous tissue and its replacement by healthy cicatricial tissue. The result of this is the production of adhesions, slight or dense, as the case may be, and which may remain fibrous or osseous; ankylosis is naturally a common termination. If, however, the condition does not improve, abscesses develop, and when opened are liable to pyococcal infection; the ligaments soften and yield; deformity is produced, and even if at length a cure is established, it is at the expense of usefulness and perhaps growth, and may be associated with deformity.

Clinical History.—The disease usually commences in a most insidious manner. It may be dated back to some injury, but as often as not no such occurrence has been noted. Slight impairment of movement, together with some pain, especially when the limb is jarred or twisted, is perhaps the first sign, causing the patient to limp if one of the lower extremities is involved. This limitation of movement is usually manifested in *all* directions, and this will often assist in diagnosing it from the fixity due to the presence of adhesions in a simple chronic synovitis. The amount of rigidity varies

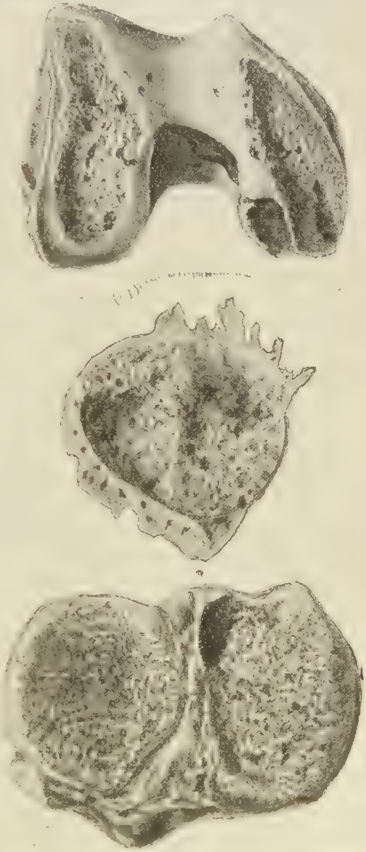

FIG. 315.—BONES ENTERING INTO FORMATION OF KNEE-JOINT, WHICH HAS BEEN DISORGANIZED BY TUBERCULOUS DISEASE. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The cartilage is almost entirely destroyed, and the exposed bone is carious and eroded.

much; in a purely synovial lesion the movements may at first be painless and but little impaired, although the whole region of the joint may be puffy and swollen; when, however, the bone is affected, either primarily or secondarily, the limitation of movement is considerably increased. The position of the limb is that which will give the greatest amount of comfort, and varies in different joints (*q.v.*) and at different stages of the disease. On inspection a superficial joint, like the knee, looks white, smooth, and rounded (constituting the ' white swelling,' or tumor albus of the older textbooks), the swelling being more apparent on account of the wasting of adjacent muscles. On palpation, the part is found to be slightly hotter than that on the opposite side of the body, whilst fluctuation is not readily detected, there being but little fluid in the joint, though the affected tissues are elastic and puffy. In a few cases, where the synovial membrane is widely involved, the affection commences with considerable serous exudation, giving rise to the condition known as *tuberculous hydrops ;* after persisting for a while, the usual manifestations of the disease show themselves. If fibrinous melon-seeds are present, a soft crepitus may be felt on moving the joint.

From time to time exacerbations of pain and increase of swelling occur, which subside after resting for a few days, but leave the joint more and more crippled. Starting pains at night develop when the cartilages are becoming eroded, together with slight fever and malaise. Sooner or later an abscess forms, with increased local and general disturbance. When it bursts or is opened, temporary relief is experienced; but fresh abscesses are liable to form. If pyogenic infection supervenes, the patient develops a hectic temperature; amyloid degeneration of the viscera may follow; the limb becomes more and more deformed; and finally the patient, exhausted partly by the discharge, partly by the pain, and partly by want of sleep, becomes emaciated, and may even die, unless prompt measures are taken for his relief.

Results.—(*a*) If seen in the early stages, and suitably treated, the disease may be entirely cured, and a moveable joint retained. (*b*) More frequently the articular structures are so severely damaged. that a cure can only be established by means of ankylosis. Unless measures have been adopted to maintain the limb in a satisfactory position, permanent deformity may ensue. This type of cure is not always satisfactory, as localized tuberculous foci may be encapsuled in the fibrous tissue, and these from time to time may cause pain and trouble. (*c*) If pyogenic organisms have been admitted, the patient will probably develop hectic or amyloid disease from chronic toxæmia, and to this he may succumb. On the other hand, in a few instances he may survive such dangers, the sinuses alternately drying up and discharging, although he remains a permanent invalid, and the joint is crippled. (*d*) Acute miliary tuberculosis is occasionally met with as a complication of this affection, or tuberculous disease of the lungs, brain, kidneys, or other viscera, may be lighted up.

The **Diagnosis** is by no means easy in all cases, although sometimes it is tolerably obvious. One can never insist too often on the importance of comparing the diseased joint with the healthy whenever possible, observing the differences in contour, colour, temperature, and mobility. The history of the case must be carefully noted, the amount and character of the effusion, and whether or not lymphocytes predominate in a cytological examination; the amount of movement must be ascertained and whether the limitation is general or particular. The opsonic index to the tubercle bacillus may also throw light on the case, and the degree and character of the reaction after a tuberculin injection. Finally, radiography may help, and particularly in distinguishing a sarcoma of the cancellated tissue of one or other of the bones forming the joint. A mistaken diagnosis in such a condition may result in loss of life, and not merely in crippling or loss of the limb, and has been made many a time with disastrous results by unqualified (so-called) bone-setters.

The **Prognosis** is mainly influenced by the condition of the individual and his surroundings. In children of the better classes, where every hygienic and medical assistance can be given, recovery generally follows, unless there is a strong counterbalancing hereditary tendency. Amongst the poorer classes, and especially in 'slum children,' the outlook is correspondingly serious. Moreover, the extremes of life are unfavourable: babies resist tuberculous invasion badly, and many patients over fifty have comparatively little recuperative power.

The **Treatment** of tuberculous joints varies not only with the articulation affected, but also with the type of patient, and the extent to which the disease has advanced.

1. *Hygienic Treatment.*—Localized tuberculosis can often be cured in the early stages by suitable local and constitutional treatment. The limb must be kept absolutely at rest by means of splints, plaster of Paris, etc., and elevated if there is much pain. Rest should include freedom not only from mobility, but also from pressure, and therefore in the lower extremity, if the patient is allowed to walk, the limb must be kept from the ground by putting a patten on the other boot. An endeavour should be made at the same time to correct any faulty position of the limb by gradual weight extension, made at first in the direction of the displaced limb, and with only just sufficient energy to keep the joint surfaces at rest and counteract the tonic muscular contraction which is tending to produce a fixed deformity. Tenotomy may be necessary to assist in this proceeding; but any form of apparatus which depends upon a screw mechanism to straighten out a limb is certain to increase intra-articular tension, and therefore is not to be used. The sudden application of force under an anæsthetic is usually unadvisable, since tuberculous material may thereby be disseminated through the system. Counter-irritation, combined with pressure, in the form of Scott's dressing, is often useful in promoting repair. The general health should be improved by sending the child to a suitable sanatorium or the sea-

side, giving plenty of good food, and administering cod-liver oil and syrup of the iodide of iron. The process of cure is slow, and the patient's friends must be warned as to the necessary length of the treatment.

2. As accessories to this hygienic treatment the following plans may be adopted:

(*a*) *Parenchymatous injections* of iodoform suspended in glycerine into the articular cavity, or into the substance of the synovial membrane, have been much employed and have apparently done good; 10 parts of iodoform are mixed with 20 of sterilized water, and made up to 100 with sterilized glycerine. A suitable quantity of this fluid carefully sterilized is injected into the joint cavity, or smaller quantities are scattered through the surrounding tissues. An inflammatory reaction usually follows, but when this has subsided—after perhaps a fortnight—the injection may be repeated. It is perhaps of most value when there is a definite effusion into the joint.

(*b*) Bier's plan of induced hyperæmia is decidedly useful, and, indeed, was first introduced in the treatment of tuberculous joints (p. 41). The method employed consists usually in the application of a rubber bandage above the joint for such a length of time as can be tolerated by the patient, usually not more than two or three hours. It is doubtful whether it is wise to employ it where septic sinuses are present.

3. *Abscesses* should be dealt with sufficiently early and in such a manner as to obviate the need for drainage. To this end they ought never to be left until the skin and subcutaneous tissues are involved, but as soon as a collection can be detected, it should be tapped by a large trocar and cannula, the cavity well irrigated, and injected with iodoform emulsion. It is wise to incise the skin with a knife, and not to puncture it with the trocar; the irregular wound made by the latter does not heal quickly; a stitch closes the incision and assists satisfactory healing.

Of course, when the skin is thin and reddened, and the pus subcutaneous, the abscess must be incised and drained in the usual manner, any thin and undermined skin being snipped away.

4. If hygienic treatment cannot be carried out satisfactorily, or if the disease progresses in spite of such measures, *operation* may become necessary; but it is remarkable how seldom the surgeon is required to undertake such cases at the present day. In this connection it must be remembered that each joint presents peculiar features, and that considerations referable to one do not necessarily hold good for another.

Arthrectomy or erasion of the joint consists in laying open the cavity and removing all the diseased tissues that can be reached. The synovial membrane is cut away; diseased foci of bone are gouged out, and the resulting cavities disinfected by carbolic acid and packed with sterilized iodoform. Ankylosis is the usual, though not invariable, result. It is obvious that this proceeding is not equally applicable to all joints. Thus, in the hip the opening is usually made from the front, and unless there is great laxity of the capsule and some increase in size of the acetabulum, the back and upper part of the joint cannot be reached. The knee, ankle, and elbow are perhaps the most favourable situations for this operation. The chief advantages of this proceeding are that it interferes neither with the immediate length nor with the subsequent growth, whilst there are no extensive sections of healthy bone exposed to infection.

Excision is a more radical measure, but has the disadvantage of removing healthy as well as diseased tissues; whilst the fact that in children it encroaches on the epiphyseal structures renders it undesirable as a routine procedure. The chief conditions for which it is now employed in tuberculous disease are as follows: (*a*) For complete disorganization of the joint, or when extensive bone mischief is present; (*b*) to prevent ankylosis in certain joints, such as the elbow and temporo-maxillary; (*c*) to determine a rapid and radical cure with synostosis in such a joint as the knee, as soon as it is evident that the natural result of the disease must be an ankylosed limb. Surgical art often produces a more efficient cure than Nature under these circumstances, since all foci can be removed. A natural cure often leaves many tuberculous foci encapsuled, and these may subsequently cause pain and lead to recurrent attacks of inflammation. (*d*) Deformity with or without ankylosis may also need excision.

Amputation is required in cases which, in spite of every care, are steadily going from bad to worse, and where the patient's health and strength are being sapped by the disease. It is needed not unfrequently in old people, and where the mischief in the bones and soft parts is very extensive. It is indicated in patients where excision has been undertaken and failed, either from the limb becoming subsequently flail-like or useless, or from recurrence owing to incomplete eradication, or from the advent of pyogenic infection. Lastly, if the disease is present in two joints at one time, or in a joint and some other organ, neither of which is improving, total removal of one focus of mischief will often induce a rapidly favourable change in the other.

The choice of operation in any particular case is not always an easy matter, and before reaching a decision several factors must be taken into consideration: (i.) The *age* of the patient. As already mentioned, the fact that typical excisions encroach on the growing ends of bones renders them undesirable in children. Even if growth is not stopped thereby, it may be rendered irregular, and subsequent deformity may ensue. As regards advanced age, opinions differ somewhat; but the shoulder and knee may be excised satisfactorily at a much greater age than the elbow, wrist, and ankle. Probably forty to forty-five years would be looked on as the age limit for the latter, but excellent results have been obtained from excising the knee and shoulder at a much later period of life. (ii.) The *general health and vitality* of the individual must be fairly good if either erasion or excision is to be undertaken. In weakly individuals amputation is often the better practice, as also when hectic fever is pronounced and amyloid disease of the viscera advanced. (iii.) The *extent* of the bone mischief. If this is slight, erasion may be undertaken; if more extensive, excision; but if the bone trouble is considerable, so that the removal of the diseased tissue would leave a flail-like, useless limb, then amputation is required. (iv.) Extensive invasion of the soft tissues may also render impracticable all treatment other than amputation. (v.) No conservative operations are justifiable in any case where an acute or subacute pyococcal or tuberculous abscess exists, or where pus is retained under pressure, as indicated by discharging sinuses and constitutional reaction. Free incisions to relieve all tension are first required, and subsequently more radical operative treatment may be considered.

Tuberculous Disease of Special Joints.

The **Shoulder-joint** is but rarely affected in children, and not very commonly in adults. The disease usually starts in the head of the humerus, affecting subsequently the synovial membrane, and perhaps also the glenoid cavity. Not unfrequently it results in ankylosis without suppuration (caries sicca). Effusion with the formation of melon-seed bodies is sometimes observed. If abscesses develop, they are likely to point either in front of or behind the deltoid, in the former case extending along the synovial membrane lining the bicipital groove. The ultimate result is usually ankylosis, with perhaps considerable shortening of the arm, or some forward displacement of the upper end of the bone simulating a subcoracoid dislocation. The case is often slow in progress, though persistent, and may be very painful. **Treatment** consists in fixing the arm to the side with a pad in the axilla to prevent inward displacement of the head. When there is much effusion, the joint may be tapped and washed out by introducing a trocar just external to the coracoid process or below the acromion. For extensive bone trouble (shown radiographically), or if the disease does not tend to improve, excision must be undertaken, and the result is often satisfactory.

In the **Elbow** (Fig. 316) the disease is most common in young adults, commencing usually in the synovial membrane, especially that of the superior radio-ulnar articulation. The swollen synovial membrane bulges on either side of the olecranon and tendon of the biceps, and can often be felt over the head of the radius, and the joint presents the typical appearance of a ‘ white swelling.’ Abscesses form by the side of the olecranon, or may burrow upwards along the ulnar nerve and open on the inner aspect of the arm. **Treatment**.—Prolonged immobilization with passive hyperæmia and suitable hygienic measures should be adopted in the first instance. The arm is kept at rest by means of a proplastic or internal angular splint reaching from the axilla to the wrist, and with the elbow bent to rather less than a right angle; the hand is kept midway between pronation and supination. If, in spite of such treatment, the case progresses, the joint should be opened in children, diseased tissues cut or scraped away, and iodoform injected. Ankylosis may follow, but no attempt to relieve it by excision should be made, or the growth of the limb may be impaired. In young adults arthrectomy or excision may be undertaken with advantage in suitable cases. The former is, perhaps, best effected by means of an **H**-shaped incision over the olecranon, which is divided at its base and turned up, so as to expose thoroughly the interior of the joint. After removing all diseased tissue, the olecranon is wired back in place. Excision is often the better practice, especially in adults, as the more extensive removal of bony tissue improves the prospects of gaining a useful moveable arm.

In the **Wrist** diffuse disease of the synovial membrane and bones is met with, starting most frequently from the former structure. If primarily osseous, it usually commences in the lower end of the radius. It may also extend from a tuberculous affection of the adjacent tendon sheaths. A characteristic doughy swelling forms over the dorsum, displacing the extensor tendons, whilst the palmar aspect of the wrist is also puffy, and the hand itself is slightly flexed, and the movements of the fingers are impaired by adhesions. Sinuses develop most frequently on the dorsal aspect or by the side of the flexor carpi radialis tendon. Conservative measures may bring about a cure, and every effort should be made to avoid excision, since the result of this proceeding is almost always the production of a weak and flail-like hand, so that the constant use of a leather support is essential after healing has occurred. In elderly people amputation is often the only resource.

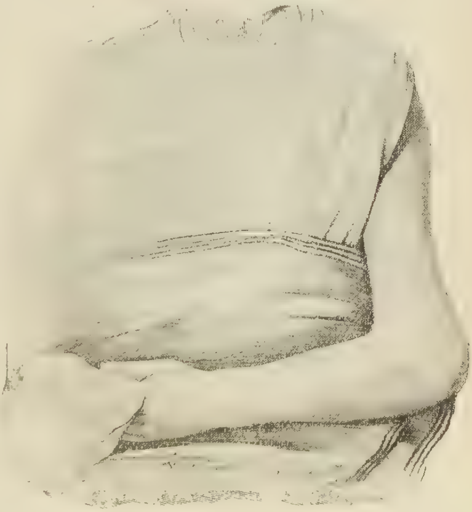
FIG. 316.—TUBERCULOUS DISEASE OF THE LEFT ELBOW-JOINT.

Diseases of the **Hip-joint** and of the **Sacro-iliac Articulation** are separately considered (pp. 668 and 677).

The **Knee-joint** is, perhaps, more often affected with tuberculous disease than any other articulation. It appears to start in the synovial membrane or bone with almost equal frequency; if the bones are first attacked, the primary focus is usually situated on the inner aspect of either the femur or the tibia. Sequestra are found in nearly one-half of the cases in which the bone is involved, becoming more frequent as the age advances. The disease runs a typical course, and needs no special comment. When the joint has become disorganized, the tibia is liable to be displaced horizontally backwards, flexed, and externally rotated, and ankylosis in this position is difficult to remedy, even by operation.

Treatment.—In the more active stages, where the joint is painful and perhaps deformity present, the patient must be kept in bed, and weight extension employed. In the later and more chronic stages, immobilization in plaster of Paris or the application of Thomas's knee-splint (Fig. 318) will prevent movement, and the use of a patten on the other foot and crutches will obviate the harmful effects of pressure from the weight of the body. The patient is then allowed to walk about, and is placed in suitable hygienic conditions. Venous engorgement and perhaps iodoform injections must also be employed, if thought desirable. Abscesses are, of course, dealt with in the usual way. If in spite of such measures symptoms persist and the case is progressive, a modified arthrectomy may be undertaken in children where growth is still continuing, and to carry it out an incision should be made across the front of the joint from condyle to condyle, as for an excision, dividing either the ligamentum patellæ, or perhaps the patella, which is subsequently wired together. The whole of the synovial membrane is then dissected away, special attention being directed to the subcrureal pouch and the back of the joint. A thin slice should be removed from the surfaces of both tibia and femur, and if the epiphyseal cartilages are not encroached upon, the growth of the limb is not impaired to any great extent, although it may become irregular and lead to some deformity—*e.g.*, well-marked flexion, or genu recurvatum. In adults, where the bones are not too extensively involved, so that on section broad healthy surfaces can be apposed, excision is a most satisfactory operation, provided, of course, that the synovial disease is also removed. As soon as it becomes evident that the only possible natural cure is by ankylosis, and this evidence would be given by fixation of the patella to the femur, or by severe

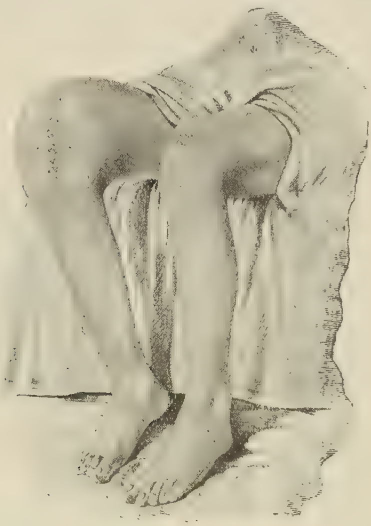

FIG. 317.—TUBERCULOUS DISEASE OF THE KNEE IN AN ADVANCED STATE.

The joint is flexed, and displacement backwards of the tibia is commencing; the smooth swollen condition of the articulation is very characteristic.

starting pains at night, excision is justifiable and advisable. It cuts short the disease, minimizes the risk of general dissemination, and provides a quicker and more radical cure than Nature can possibly effect. Incomplete removal of the disease, either in the synovial membrane or bone, may determine recurrence; if this cannot be dealt with effectively, amputation may be required, and then a long posterior flap is the only healthy tissue available for covering the bone. Under other circumstances the ordinary supracondyloid amputation can be adopted.

The Ankle-joint.—Tuberculous disease of this joint usually commences in the synovial membrane rather than in the bone. The whole region becomes occupied by a pulpy swelling, which first pushes forwards the extensor tendons and bulges in front of the malleoli, and subsequently appears on either side of the tendo Achillis. There is often but little pain, and the movements of the ankle are often but little impaired; the calf muscles are usually wasted. In the later stages, when the bones are involved, the foot is maintained in a position of slight plantar-flexion, so as to bring the narrower portion of the upper surface of the astragalus into the tibio-fibular mortice. Flexion and extension of the foot are usually limited or lost, but with care the lateral movements (inversion and eversion) which occur at the mid-tarsal and sub-astragaloid joints can be undertaken without pain. If the disease is primarily osseous, localized painful areas occur over the lower ends of the tibia or fibula, or over the astragalus, and the osseous lesions can be demonstrated by radiography. In either type of case, abscess formation is very liable to follow, and may become extensive, owing to the implication of tendon sheaths. **Treatment.**—In the early stages prolonged rest and immobilization in plaster of Paris or a Thomas's splint are required. Operative treatment is not very satisfactory. Arthrectomy can be undertaken, but removal of the astragalus and of all available synovial membrane is probably a better course to adopt. When, however, the astragalus is involved, it is often difficult to eradicate the disease, which has probably spread to the articulations and bones beneath it, and amputation may then be required. Where the disease also involves the tibia and fibula, a supra-malleolar amputation of the foot will probably be necessary.

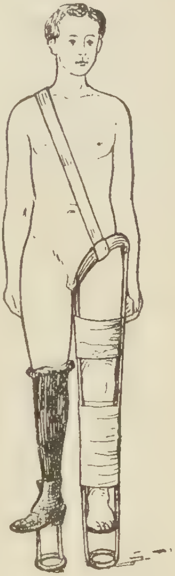
FIG. 318.—THOMAS'S KNEE-SPLINT APPLIED.

For diseases of the **Bones and Joints of the Foot,** see p. 573.

Syphilitic Diseases of Joints.

Although syphilitic disease of joints is rare in proportion to the prevalence of syphilis, yet several varieties have been differentiated and recognised. (1) In the later stage of the secondary period a *chronic* form of *synovitis* occurs, evidenced by passive effusion into the joint, with or without pain, and usually persisting for some time. Any joint may be attacked in this way, perhaps the knee most commonly, and the affection is often symmetrical in its distribution. The effusion may be only slight, but is frequently very considerable (hydrarthrosis), and a marked feature in the condition consists in the rapid variations in the amount of swelling, even from day to day. In some few cases this affection resists all treatment, and leads to ultimate disorganization. (2) Gummatous inflammation of the peri-synovial fibrous tissue, which may or may not extend to the adjacent bone, is met with in the tertiary period. It either appears as a localized hard nodule, resembling in measure a fibrous tumour, and then causing but little trouble beyond a sense of painful weakness in the articulation; or it is more diffuse in its distribution, leading to a moderate effusion, and later on to much thickening and infiltration of the capsular and other ligaments, and resulting in considerable impairment of its movements from cicatricial contraction. Some of these gummatous nodules may break down and ulcerate. (3) A diffuse *gummatous infiltration of the synovial membrane* itself is also seen, usually in children. It closely simulates a tuberculous synovitis, from which it is often impossible to distinguish it, except by the rapid onset, the absence of pain, the greater amount of effusion, and the symmetry which is sometimes present. It may occur apart from other evidences of congenital syphilis. (4) A *chondro-arthritis*, described originally by Virchow, is the syphilitic analogue of osteo-arthritis. It commences by fibrillation of the matrix of the cartilage, and proliferation of the cells. The cartilage softens, and becomes eroded by friction of the articular surfaces. The bone thus exposed is worn away, and curiously 'pitted' or excavated. It is distinguished from osteo-arthritis by the facts that there is usually but little or no pain; that the eburnation of the exposed bone is less extensive, and therefore crepitus is but little marked; whilst the typical osteophytic outgrowths and 'lipping' of the joint margins are absent. The eroded areas, moreover, do not correspond with the sites of intra-articular pressure, and are more rounded and punched out, and not arranged in linear grooves, as in the latter disease. It is not uncommonly associated with a gummatous thickening of the synovial membrane, and, indeed, the hollows or pits above mentioned may be filled with caseous material, derived from degeneration of this tissue.

The **Treatment** in the early manifestation consists in the administration of mercury or salvarsan, and the judicious application of pressure with or without immobilization, according to the requirements of the case and the joint affected. In the tertiary forms iodide of potassium in gradually increasing doses has a rapidly beneficial action, which confirms the diagnosis; it may be occasionally combined with a small amount of mercury, either given internally or applied locally if any ulcerative lesion exists. In the most pronounced cases, where the pain is severe and disorganization of the joint has occurred, excision may be necessary, and the results are often very satisfactory.

Osteo-Arthritis.

Although this disease is extremely common in this country and has well-marked characteristics, its nature is still obscure, as is evident from the number of names applied to it, such as *chronic rheumatoid arthritis*, *rheumatic gout*, *arthritis deformans*, *arthritis senilis*, *arthritis sicca*, etc. There is not the slightest doubt that several types of disease have been confounded together under this title, and although rheumatic and gouty conditions are now excluded, yet it is probable that we are still including more than one type of chronic articular trouble.

Under these circumstances it is a little difficult to speak dogmatically as to **Ætiology.** 1. *Infection* plays an important part in the production of certain types of the disease. The organisms find their way into the joints from some other focus of infection, and in this connection it is interesting to note the statement that in a large series of cases 55 per cent. were preceded by some other infective disease, such as influenza (Bannatyne). The bacteria develop in the joints, and produce toxic bodies which act locally by inducing destructive phenomena of a special type, whilst by their general absorption various trophic and nervous symptoms are caused, whose existence has been constantly noted, but for which hitherto there had been no adequate explanation. Such an origin will also explain the enlargement of the spleen and of lymphatic glands in the neighbourhood of some of the affected articulations (Still). Several observers have found bacteria within the joints, and Bannatyne amongst others has described a short bacillus, the ends of which stain deeply, whilst the intervening portion remains unstained, causing it to look like a diplococcus.

2. *Auto-intoxication* is another probable cause of many cases. It has been already pointed out that the absorption of toxins from the mouth or elsewhere may lead to chronic osteitis and arthritis (pp. 85 and 590), and it is probable that other forms of intoxication may suffice to determine the onset of osteo-arthritis. It may be noted that the affection has been often associated with uterine and ovarian disease, and with various forms of indigestion.

3. *Exposure* to damp and cold is an important ætiological factor, especially in elderly people, as also worry, fatigue, depressing nervous and mental conditions, deficient food, and bad hygiene. It is quite possible that many of these conditions act by producing some form of toxæmia, perhaps of intestinal origin.

4. *Traumatism* is frequently responsible for a chronic inflammation of joints, which may be known as *chronic traumatic arthritis;* the changes are practically identical with those of osteo-arthritis. The injury may be slight in nature, such as a sprain or strain, or more severe, such as a fracture or dislocation involving the articular surface; thus, it is not uncommon to see it following Colles's fracture or one of the cervix femoris. Abnormal pressure maintained for a long time also causes changes of a similar type, and thus many of the joints of labouring men are deformed in a peculiar fashion, according to the special type of work and the particular joints that are exposed to strain. To this variety the term *arthritis deformans* may well be applied.

5. Lastly, *senile degeneration* also seems to produce articular lesions of a very similar character.

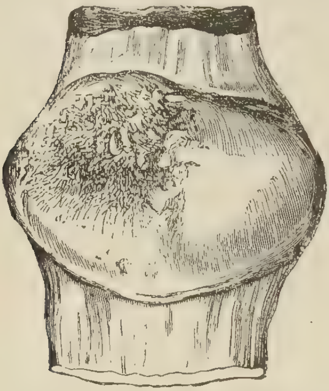

FIG. 319.—PATELLA FROM EARLY CASE OF OSTEO-ARTHRITIS, SHOWING FIBRILLATION OF CARTILAGE. (HOWARD MARSH.)

Pathological Anatomy.—The disease may commence either in the synovial membrane or in the articular cartilage, but perhaps more frequently in the former, particularly in the acute and subacute varieties. In the early stages the synovial membrane becomes vascular and thickened, and the villi proliferate so that the surface becomes shaggy or villous in appearance. Sometimes the villi reach such dimensions that they can be felt through the skin, rolling under the finger; they are red, vascular, and succulent during life, but after removal and preservation in spirit they look shrunken and insignificant. At times there is a considerable development of fat in these villi, constituting the condition known as *lipoma arborescens*, and often associated with an added element of gout. Occasionally cartilaginous nodules are found in the villi, and these may subsequently undergo ossification; if detached, they may constitute one form of loose body in a joint. When the disease develops along these lines with marked synovial changes, effusion is usually considerable and early; in other cases there is often but little effusion, so that the affection has been termed 'arthritis sicca.'

The changes in the cartilage, whether primary or secondary, consist in a breaking up of the matrix into fibres, the so-called 'fibrillation,' so that the surface becomes rough like the pile on carpet or velvet (Fig. 319). Meanwhile the cartilage cells are arranged in longitudinal rows between the fibrillæ and proliferate within their capsules, which become distended and burst into the joint. The cartilage thus softened is readily worn away by the movements of the articulation, and the surface of the bone is exposed. Concurrently with this destruction hyperplasia is taking place at the margins of the articular cartilage, resulting in the production of irregular overgrowths (ecchondroses), which have been likened to the gutterings of a candle. In them ossification occurs secondarily, and when such overgrowths have been produced more or less evenly around the joint margin, a characteristic lipping of the edge of the articular surface results (Fig. 320). Sometimes these osteophytes attain considerable dimensions, and by interlocking may lead to ankylosis of the joint.

The bone exposed by the destruction of the articular cartilage is altered as the result of the movements of the joint. The chronic irritation causes it to become hard, sclerosed, and polished like ivory (eburnation). This usually occurs in certain definite directions; in hinge joints the surfaces become grooved longitudinally, whereas in ball-and-socket joints like the hip the head is eburnated in a circular manner. This condensed tissue does not extend very deeply, and immediately beneath it the bone is of a more open texture than usual and filled with fatty medulla. In spite of the sclerosis the articular end of the bone is being constantly worn away, and this may progress to such an extent as to lead to actual shortening of the limb.

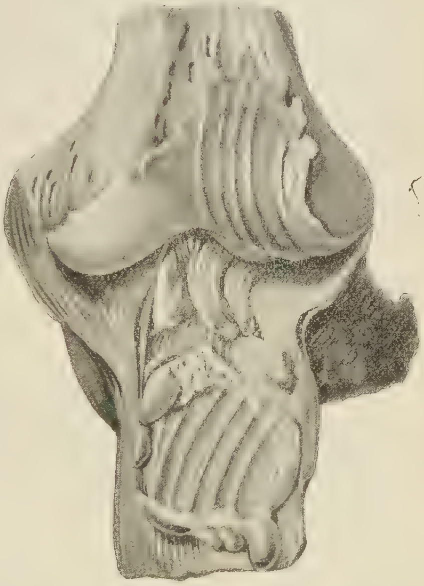

FIG. 320.—LATE STAGE OF OSTEO-ARTHRITIS OF KNEE, SHOWING DESTRUCTION OF THE ARTICULAR CARTILAGE, AND EBURNATION OF THE EXPOSED BONE IN LONGITUDINAL GROOVES. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The margins of the cartilages are distinctly lipped.

Clinical History.—Three chief types of this disease may be described:

1. The *chronic monarticular variety* is that most frequently seen by surgeons, and is constantly brought about by injury. Pain and creaking of the joint on movement are the early symptoms. There may be very little swelling, unless effusion is present, but pain, especially at night, is most troublesome, being usually increased on changes of weather, particularly if rain is threatening. The pain and stiffness are most marked after keeping the parts at rest, and

diminish when the limb is used. As the disease progresses, the movements become more and more impaired, and the creaking may be transformed into a true bony crepitus; the ends of the bones are felt to be enlarged and lipped, and deformity soon becomes obvious. Exacerbations in the symptoms occur from time to time, resulting in increased crippling. Finally, the limb may become absolutely useless, partly from the pain and partly from the limitation of movement produced by the osteophytes. Wasting of the adjacent muscles is also a marked feature.

This variety is usually seen in elderly people, and may supervene quickly after an accident, such as fracture or bruising of the cervix femoris, and then the destructive phenomena may progress at a rapid rate. When it appears in younger people, the osseous lesions are much less evident.

2. The *chronic polyarticular variety* arises independently of traumatism, and is most commonly seen in females of middle life. It may commence in one joint and spread to others, or it may appear in many joints simultaneously. Most frequently one or more of the phalangeal articulations is the starting-point, particularly the terminal ones, and then it may be the result of an injury. The joints become stiff and swollen, are tender, and in the milder cases small nodular bony outgrowths develop at the bases of the phalanges, which are known as Heberden's nodosities. Gradually some degree of flexion occurs, accompanied by increasing stiffness and ulnar adduction of the fingers, which renders the hands very helpless (Fig. 321). The trouble gradually spreads to other joints, and although there are often remissions, yet the condition progresses steadily until the patient may be entirely crippled thereby. Well-marked overgrowth of bone and eburnation of the articular ends are characteristic features of this type. Sometimes there is considerable effusion, accompanied by overgrowth of the synovial villi, but this is unusual.

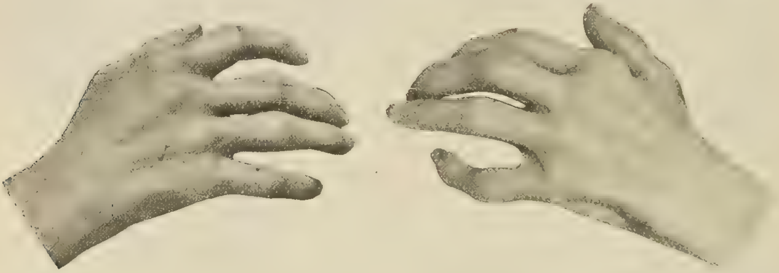

FIG. 321.—HANDS OF PATIENT WITH CHRONIC POLYARTICULAR OSTEO-ARTHRITIS, SHOWING NODULAR CONDITION OF THE JOINTS AND MARKED FLEXION AND ULNAR ADDUCTION.

3. The *acute polyarticular variety* does not often come to the surgeon for treatment, at any rate in the early stages. It usually attacks

young or comparatively young people, and females rather than males, frequently following some infective trouble, such as influenza, scarlatina, tonsillitis, etc. It is often ushered in by a distinct febrile attack with persistent increase in the rate of the heart-beat; trophic and vasomotor phenomena are often co-existent, such as patches of pigmentation, clammy cold hands, and rapid muscular atrophy. The smaller joints of the hands and feet are mainly affected, and that more or less symmetrically, although the terminal interphalangeal articulations often escape. The capsules are distended with a certain amount of effusion, causing the joints to look spindle-shaped, and at first there is but little osseous mischief. In not a few cases a very characteristic deformity in the shape of ulnar adduction of all the fingers occurs. Gradually the trouble spreads to other and larger joints, and osseous manifestations appear; but the progress is slow, and may be to a large extent arrested by treatment. Neighbouring lymphatic glands may be enlarged in the early stages.

The peculiarities of this affection, as it involves children, have been emphasized by Dr. Still. Girls are more often attacked than boys; many joints are implicated, and neighbouring lymphatic glands are enlarged. The cartilage is but little altered, and bony outgrowths are absent. The spleen is also enlarged, and there may be pericardial and pleural adhesions.

It is important to note that gouty and rheumatic troubles may be associated with osteo-arthritis: the rheumatic affections may precede, the gouty usually follow.

The **Diagnosis** of osteo-arthritis *per se* is not often difficult in a well-marked case, the crepitus, pain, and enlargement of the ends of the bones, together with the slight amount of effusion, constituting a tolerably characteristic picture. Radiography may show the characteristic lipping of the articular ends, and the thinning of the bony substance beneath the cartilage. From simple *chronic synovitis* it may be known by the history and smaller amount of effusion, and by the pain and rigidity being frequently more marked after rest, and diminishing after the joint has been actively used. There is more difficulty in distinguishing the form associated with increased effusion and enlargement of the synovial villi; careful examination may however, enable the surgeon to make out these villi moving to and fro in the joint under his hand, whilst possibly the ends of the bone may be lipped. For diagnosis from *chronic rheumatism* and *Charcot's disease*, see pp. 638 and 661.

The **Prognosis** is usually unfavourable. The fact that many joints are affected is an indication that there is a considerable constitutional element in the evolution of the disease, and, although it may be temporarily combated with success, still, sooner or later, the patient is almost certain to be crippled by it. The affection of only one joint often points to a traumatic origin, and the outlook is correspondingly brighter; but where the disease attacks several parts of the body, there is but little hope of checking it, and indeed cases are known in which every joint has successively become implicated, the patient dragging on a weary existence, never free from pain, and usually in a cramped or sitting posture, until death from exhaustion supervenes.

Treatment.—For this troublesome complaint there is, unfortunately, little that can be effected in the way of cure, although much can be done to alleviate. Locally, the articulations should be protected from cold and injury by being swathed in flannel, whilst stimulating embrocations and sedative applications may be beneficially employed. It is not advisable to maintain the joints absolutely at rest, otherwise their mobility is likely to become seriously limited at an unnecessarily early date. Moreover, it is often found that the more a joint is moved, the easier and less painful do the movements become, and hence regular massage is desirable. Hydrotherapy, electrotherapy, and treatment by the local application of heat (Chapter III.) have a large field of usefulness in this affection. As to general treatment, the individual is warned against exposing himself to cold and damp, and since the disease is often considered to be due to perverted or diminished nervous activity, all possible sources of irritation and worry should be removed. At the same time the nutrition must be improved, and plenty of good food, cod-liver oil, etc., administered. A large number of different drugs have been tried for this complaint, but none of them are very satisfactory. Perhaps the best is iodide of sodium combined with some alkaline purgative and hepatic stimulant, such as sulphate of soda. Natural mineral waters and baths are often beneficial, those of Bath and Buxton in this country being most frequently recommended, though the sulphur waters of Harrogate and Strathpeffer are also beneficial. Arsenic is sometimes useful.

Occasionally operative treatment in the shape of *excision* may be undertaken in this complaint, but only when the disease is limited to one joint, and when it has progressed to such a stage as seriously to cripple the patient's usefulness, as in the knee-joint, elbow, or the shoulder, or when the act of mastication is impaired, owing to an affection of the temporo-maxillary articulation. In suitable cases excellent results are obtained. The possibility of excising the osteophytic growths has also been mooted, and in suitable cases it may be attempted.

The *hip-joint* is not uncommonly the seat of osteo-arthritis in old people, and it always causes a considerable amount of pain, especially on flexion of the limb, rendering sitting difficult and walking uncomfortable, whilst the movements become more and more curtailed. The limb early appears to be shortened, but this is in reality due to its adduction and a compensatory tilting up of the pelvis on the affected side so as to maintain the parallelism of the legs. The adductor muscles will usually be found tense and contracted, and abduction of the limbs is markedly diminished, even at a time when flexion is scarcely limited at all. At a later date true shortening follows, with, perhaps, increased deformity, owing to erosion of the head and excavation of the acetabular cavity, which is enlarged upwards by the absorption of its posterior lip. Well-marked lipping of the acetabular margin and head of the femur occur, and thereby much impairment of movement is produced and easily elicited crepitus. The trochanter is unduly prominent in most cases where true shortening is present, and this is an important diagnostic sign, especially when a fracture of the neck is suspected in a patient who has fallen on the hip. **Treatment** in these patients is important, inasmuch as serious crippling is caused by the disease. In cases which have progressed beyond the stage when hydrotherapy can help, mechanical means must be adopted to diminish intra-articular tension, and thereby prevent the bones from mutual attrition, although it is still desirable to permit walking. This is best effected by the application of a Thomas's splint with fixed extension, and yet permitting mobility of the joints. The limbs must first be extended under an anæsthetic, and, if need be, the adductors must be divided so as to correct the deformity. A cast of the pelvis is taken, and a leather-moulded splint fitted to it, from which the Thomas's splint takes its *point d'appui*. Very satisfactory results of such treatment have been obtained in suitable cases, and that with but little recumbency.

When the *temporo-maxillary joint* is affected, the condyle of the jaw becomes larger than usual and somewhat flattened; the eminentia articularis is partially absorbed and the glenoid cavity increased in size, so that the condyle is liable to slip forwards owing to the action of the external pterygoid muscles. If only one joint is affected, the bone is carried towards the sound side, but when both are involved the chin becomes prominent owing to a forward displacement of the whole bone. Pain and crepitus are experienced on opening the mouth, rendering mastication difficult, and even impracticable. If ordinary treatment fails to give relief, the affected condyle of the jaw should be excised.

Neuropathic Arthritis (*Syn.:* Charcot's Disease).

This disease, bearing the name of the late Professor Charcot, is a peculiar affection of joints met with in the course of locomotor ataxy. It is slightly more common in women than men, and is almost always an early manifestation, occurring usually between the lightning-like pains and the onset of the ataxic symptoms. The most typical form is lighted up by some slight injury—*e.g.*, a strain or sprain—and is characterized by a rapid painless distension of the joint with a light-coloured serum, which may also extend into the communicating bursæ; there is some amount of effusion into the surrounding cellular tissue, although without œdema. This distension may be so rapid that abnormal mobility or even dislocation may occur at the end of a few hours. The joints most frequently affected are the knee, hip, and shoulder; occasionally more than one articulation is involved. The course of the case varies; in some few instances the fluid is gradually absorbed and the joint returns to its normal size and shape, although somewhat weakened. Sometimes the attacks of distension recur, and after each the joint becomes more and more crippled. Two chief types of the affection are described: (1) In the *atrophic* variety, the more common, the bones becomes eroded to a considerable extent, the ligaments stretched, and a weak, flail-like articulation remains, in which the ends of the bones are atrophied and displaced (Figs. 323 and 324). (2) In the *hypertrophic* form new osseous formations occur here and there under the synovial membrane, especially in cases where there is much distension, so that on compression of the swelling between the hands a sensation is produced similar to that imparted by grasping a bag of bones. After a time these osseous masses become welded together, giving rise to large overgrowths, which lead subsequently to fixation of the joint (Fig. 322). The disease sometimes runs a more chronic course, and then closely resembles osteo-arthritis, since there is but little effusion, whilst the ends of the bones become eroded, and osteophytes, perhaps of great size, form around the edges of the cartilages, leading to defective mobility and crepitus.

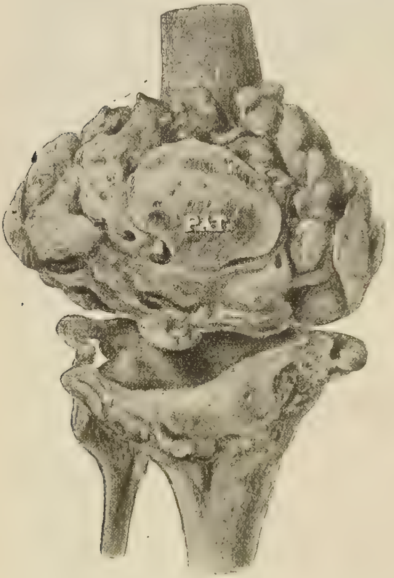

FIG. 322.—HYPERTROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The patella (PAT.) can be seen poised on the top of a mass of new bone formed by the welding together of a number of smaller portions formed in the perisynovial tissues.

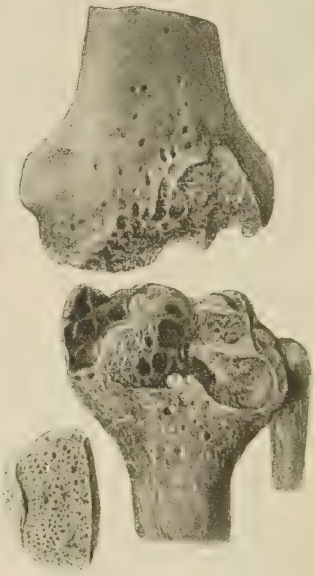

FIG. 323.—ATROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The bones are cleanly eroded, and no new formation is present. The patella is reduced to a mere shell, one-eighth of an inch thick.

The **Diagnosis** of Charcot's disease from *osteo-arthritis* is, as a rule, readily made if one remembers the following points: Charcot's disease is usually characterized by a rapid onset, limitation to one joint, considerable effusion, absence of articular pain, atrophy of the ends of the bones, and a tendency to the production of a weak, flail-like joint, whilst the early general signs of tabes are also observed, especially the lightning pains and the Argyll-Robertson pupil. Osteo-arthritis, on the other hand, comes on slowly, often affects many joints, has but little effusion, is very painful, and is attended with marginal overgrowth or lipping of the cartilages. In the more chronic cases the distinguishing features are much less evident.

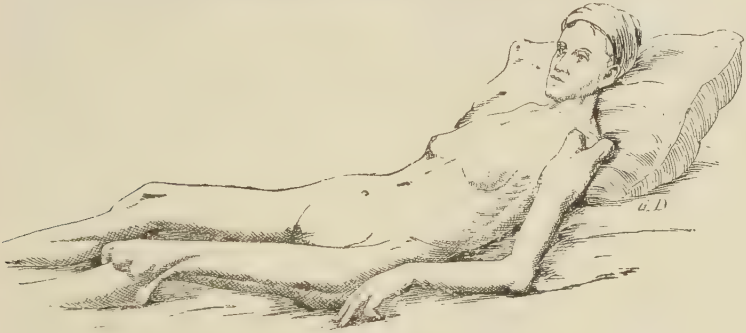

FIG. 324.—CHARCOT'S DISEASE OF LEFT KNEE AND SHOULDER.

The great atrophy of the ends of the bones, and the resulting dislocations, are clearly evident.

As to pathological anatomy, the changes observed are practically identical with those seen in osteo-arthritis, except that the erosion is more rapid, the effusion greater, and the formation of osteophytes less constant.

The **Treatment** of Charcot's disease consists in keeping the limb at rest on a splint and applying elastic pressure. The effusion, when considerable, may be removed by an aspirator, but is very likely to re-collect. Ionic medication with salts of iodine may be of use. In the later stages, where the joint is entirely disorganized, some form of fixed apparatus, such as a carefully moulded splint, may be applied to render the limb more useful, and it is remarkable how well a patient can get on in this way with a badly-affected joint. In the worst cases, however, amputation may be required.

The same type of articular lesion occurs in *Syringomyelia*, a disease which consists in a gliomatous development in the spinal cord, and usually in the cervico-dorsal region. It is characterized by loss of the senses of pain, and of heat or cold, but tactile and muscular sensibility persists. Atrophy of various muscles of the hand or fore-arm also occurs, whilst trophic lesions—*e.g.*, whitlow, perforating ulcer, etc.—are common. Joint troubles are observed in at least one-third of the cases, mainly in the upper extremity, tabes generally affecting the lower. Either atrophic or hypertrophic phenomena are developed, and the course is identical with that of Charcot's disease, except that suppuration is a little more likely to follow, owing to the frequent presence of infected sores.

Somewhat similar in nature to Charcot's disease is the chronic arthritis met with in many conditions where the nervous supply to a limb is impaired as a result of central or peripheral disease of the nervous system. Thus, it may follow spina bifida, hemi- or para-plegia of cerebral or spinal origin, or may be secondary to a peripheral neuritis, due to either injury, syphilis, gout, diabetes, leprosy, etc. The terminal articulations of fingers or toes are those most often affected (acro-arthritis), although larger joints may be involved. They become swollen and painful, and after a time ankylosis ensues.

Hæmophilic Diseases of Joints.

In hæmophilia (p. 298) any injury to a joint may lead to a copious effusion of blood into the articular cavity, which becomes suddenly swollen and distended. The part becomes hot and tender, whilst when coagulation has taken place it is hard and firm. Total recovery may ensue, or the joint be left weak and liable to recurrence of hæmorrhage. The effects of recurrences on the articular surfaces are curious: the cartilages usually retain their normal colour, but become thin, worn, and rough, especially at the points of greatest pressure; fibrillar degeneration of the matrix may occur, and in some cases the cartilage has been found totally absent, being replaced by fibrous tissue. Ecchondroses subsequently developing into bone are formed at the margins of the joint surfaces, the changes thus produced being somewhat akin to those of osteo-arthritis. The ligaments and synovial membranes are slightly thickened, and usually of a russet-brown colour. Adhesions are often present, causing considerable impairment of mobility. The *Treatment* consists in keeping the part at rest, and applying ice in the early stages; whilst, later on, friction, massage, and pressure may be employed. The surgeon must never attempt to aspirate the joint, even with a fine needle.

Loose Bodies in Joints.

Several varieties of loose body are met with in joints, which may be described as follows: (1) The so-called ' melon-seed bodies ' consist of fibrin derived from altered blot-clot, or more frequently from a fibrinous exudation in cases of very chronic tuberculous disease. At first irregular in shape and laminated in texture, they are generally transformed into round or flattened pellets or elongated masses by the movements of the articulation. Bursæ and tendon sheaths are much more frequently affected than joints. The number present is usually considerable, whilst there is also some glairy effusion, causing distension and a certain amount of creaking. In one case the knee-joint was occupied by a number of rounded yellowish-white translucent foreign bodies, several of which were nearly as large as walnuts; they were probably of hæmorrhagic origin. (2) Portions of articular or intra-articular cartilage may be broken or are separated off as a result of direct mechanical violence. They usually consist of a smooth rounded mass of articular cartilage enclosing a central bony nucleus (Fig. 325). The most common situation for this to occur is the lower end of the femur; when the knee is fully bent, the articular surface is exposed to direct violence. If not broken off immediately, the injured fragment may be separated without pus formation; it is sometimes found attached to the under side of the femur by a pedicle of fibrous tissue, which allows of only a limited mobility. (3) They are sometimes derived from the development of cartilaginous nodules in the synovial fringes or villi, which either may become pedunculated, then occasionally wearing a bed for themselves in the articular surface, or may be totally detached. Such structures are usually lobulated and irregular in shape, and consist of calcified cartilage or bone, whilst a certain amount of normal cartilage is also present (Fig. 326). This condition may result from osteo-arthritis, but sometimes the cartilaginous cells from which they are derived have persisted as a 'fœtal residue.' (4) Ecchondroses may be broken off in cases of osteo-arthritis, or even portions of the articular cartilage showing well-marked villous changes.

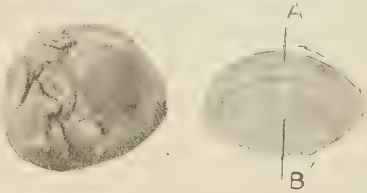

Fig. 325.—Foreign Body in Joint probably derived from a Portion of Articular Cartilage. (From College of Surgeons' Museum.)

A, Cartilage; B, bone.

Although cut off from all vascular supply, the growth of some of

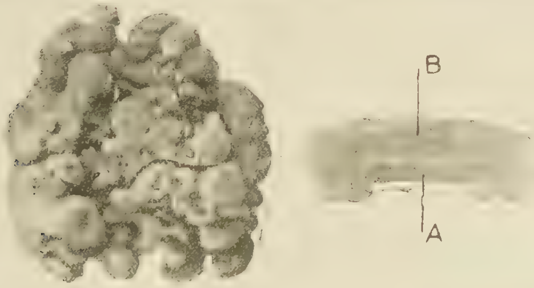

Fig. 326.—Loose Cartilage in Joint, probably developed in a Fringe of Synovial Membrane. (From College of Surgeons' Museum.)

A, Cartilage; B, bone.

these loose bodies is said to continue, owing to the highly nutritious fluid which bathes their surfaces.

The **Symptoms** caused by this condition are produced by the loose body being occasionally caught between the articular surfaces, leading to a temporary locking of the joint, and severe pain, owing to the stretching of the ligaments. The fixation is but momentary, since the foreign body is readily displaced, but an attack of subacute synovitis follows. When this has happened several times, the ligaments are likely to become relaxed, and the joint somewhat loose and distended. Under such circumstances it may be possible to feel the foreign body and to shift its position, but frequently the surgeon is unable to detect the intruder as it slips away into the interior of the joint, owing to its ready mobility. From this point of view, the German term ' Gelenkmaus ' (joint mouse), as applied to this affection, is most happy. The knee-joint is that most frequently affected, but the same condition occurs in the elbow and temporo-maxillary articulation.

The **Diagnosis** between a loose body and a torn and *moveable semilunar cartilage* in the knee-joint is not always easy, since in both conditions painful locking of the joint occurs. The fixation, however, is but momentary in the case of a loose body, but may persist until reduced in the latter, whilst a localized spot of tenderness may be detected corresponding to the site of the injury to the interarticular cartilage. Moreover, the history of the case is very different, since the dislocation of a semilunar cartilage is always primarily referred to some twist or sprain of the joint, whereas with a loose body no such traumatic influence need be present. It is sometimes possible to detect a loose body by the X rays if there is any osseous tissue in it.

The **Treatment** consists in the removal of the foreign body by an open operation. In the knee-joint a vertical incision should be made about 2 inches in length, extending a little above and below the line of the articulation. It should be placed about 1 inch from the patella, on whichever side the loose cartilage presents most frequently, but preferably on the outer. If possible, the foreign body should be fixed by the finger in one of the lateral pouches of the joint before making the incision. The capsule and synovial membrane are opened, the loose body removed, and the cavity carefully closed. For precautions, etc., see p. 629.

Neuralgic Joints.

In neurotic individuals, especially young women, a neuralgic condition of the joints is commonly met with, simulating disease of the articulation. On careful examination the pain is found to be superficial, not increased by jarring the articular surfaces together, and often not strictly confined to the joint. The movements are apparently limited, but if the attention of the individualis diverted, or anæsthesia induced, they are found to be perfectly free. There are no signs of effusion into the cavity, and no starting pains at night. Occasionally a similar condition is met with in men, where there is no suspicion of hysteria.

The *treatment* is constitutional and local. The former is directed towards improving the general health, and correcting any error in the uterine functions. The latter is best accomplished by the use of cold douches and electricity, although counter-irritation in the shape of blisters, or even the actual cautery, applied over the joint, has an excellent moral effect.

Ankylosis.

By ankylosis is meant a condition of immobility, partial or complete, of a joint, resulting from some preceding inflammation of the articular structures.

The term *false* ankylosis is sometimes applied to a condition resulting from extra-articular lesions. Such may be either fibrous or osseous, and is due to cicatricial contraction of the skin, shortening or fibrosis of muscles, or even to the development of bony tissue within them (*myositis ossificans*). *True* ankylosis always involves the articular structures, and is either fibrous or bony.

Fibrous or incomplete ankylosis results (*a*) from thickening and contraction of the ligaments, such as often occurs after gonorrhœal or rheumatic affections; (*b*) from the formation of cord- or band-like adhesions within the joint, after acute synovitis or fractures involving the articular surface; (*c*) from erosion of the cartilage and exposure of the bone as in acute or tuberculous arthritis; granulations sprout up on each side, and by their union lead to dense fibroid adhesions between the articular surfaces. Some amount of movement is possible in most of these cases.

Complete or osseous ankylosis (synostosis) arises from the union of either the whole or part of the opposing surfaces left by the destruction of the cartilage, the bond of union, at first fibro-cicatricial, being subsequently ossified (Fig. 327); it may also be due to the interlocking and fusion of osteophytes, formed at the margin of the bone in osteo-arthritis or Charcot's disease.

The position in which ankylosis occurs and the *effects* thus produced differ according to the joint affected.

In the *shoulder* there is usually but little displacement, and the existence of immobility is of less importance than elsewhere, owing to the free movements of the scapula and clavicle. The deltoid muscle is generally much atrophied. The *elbow-joint* is very commonly ankylosed on account of its exposed position, and the frequency of fracture-dislocations in its neighbourhood. The formation of callus filling up the olecranon and coronoid fossæ, and the adhesions likely to form within the joint in these cases, readily explain its frequency. The most favourable position for ankylosis is when the arm is flexed to a little more than a right angle, with the hand midway between pronation and supination. By this means access to the mouth is possible, and the patient can use his hand for feeding purposes. Occasionally, however, the patient's work is such as can best be undertaken by a straight arm. The *wrist* is most commonly fixed as a result of gonorrhœal or rheumatic synovitis. In the *hip-joint* (Fig. 327) much depends upon the treatment as to whether the ankylosis takes place in a good or bad position. In neglected cases the thigh may be in a position of adduction and internal rotation, crossing in front of the other leg. Occasionally a *scissor-like deformity* has resulted from inflammation of both hip-joints, one leg lying in front of the other; progression is accomplished with difficulty, the body twisting at each step, and crutches are often needed. In the *knee-joint* ankylosis in an absolutely straight position of the limb should be aimed at, unless complete synostosis is likely to occur, when a slight degree of flexion may render the leg more serviceable. Unless care is taken in treating the causative affection, ankylosis is only too likely to be associated with deformity. The knee becomes bent, and the tibia is displaced backwards on the femur, whilst external rotation and even lateral displacement of the tibia externally are likely to supervene if the patient is allowed to lie with his leg on its outer aspect. In the *ankle-joint* considerable trouble may arise from immobility, unless the foot is at right angles to the leg.

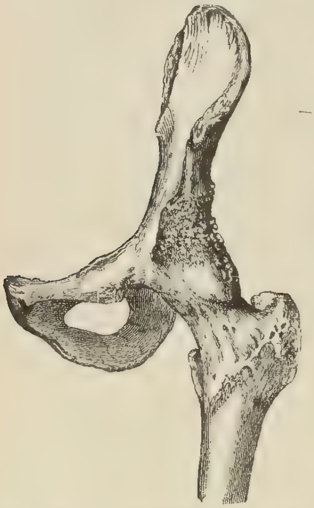

FIG. 327.—ANKYLOSIS OF HIP-JOINT IN GOOD POSITION AFTER EARLY HIP DISEASE. (HOWARD MARSH.)

It must always be remembered that in a case of long-standing ankylosis the changes do not involve only the articular surfaces. The bones themselves after a time may become atrophic and break easily; ligaments are shortened, or transformed into bony tissue; muscles are atrophied, and in time undergo complete degeneration; tendons may be ossified; and in cases of deformity, accommodative shortening occurs in all the tissue involved, muscles, tendons, nerves, vessels, etc. Hence the *prognosis* of all operative treatment directed to the cure of the ankylosis involves a careful consideration of the condition of the soft parts, and the possibility of their being restored to functional utility.

The **Treatment** of ankylosis must vary considerably according to its cause. In the simple forms of *fibrous* ankylosis, due to the presence of adhesions of no density, much may be done by manipulation, massage, and exercises. Some adhesions may be dealt with by forcible movements under an anæsthetic, the surgeon ever keeping in mind that the bones involved may be atrophic and easily broken. Others are better treated more gradually, efforts being directed to lengthen and loosen the adhesions rather than to break them. A course of fibrolysin (p. 263) may sometimes help in this direction by softening the fibro-cicatricial bands.

An exception to all vigorous treatment of this type, as also to the operative methods suggested below, is made in the case of ankylosis following tuberculous disease. The surgeon can never be certain that infective foci are not encapsuled in the fibrous tissue, and active treatment might once again light up active disease.

It is useless to attempt the rupture or division by open operation of dense adhesions, as they are certain to re-form. These cases, as also certain non-tuberculous forms of osseous ankylosis, are best treated by the operation of **arthroplasty**, elaborated by J. B. Murphy. The procedure is based on the recognised fact that one of the most frequent causes of the non-union of fractures is the interposition of fibrous or muscular tissues between the fragments. If, then, the articular ends of an ankylosed joint can be separated, and a suitable flap of tissue interposed, the free movement of the joint should be restored. Much experimental work has been undertaken to ascertain the best material for this purpose: gold beater's skin (or ox's peritoneum = Cargile membrane), Baer's membrane (chromicized and sterilized pig's bladder), and free or pedunculated fascial flaps, have been chiefly used; on the whole, the best results have been obtained from free fascial flaps stitched over the bone ends. It is impossible here to enter into lengthy details of the procedure*; it must suffice to state that the joint affected must be freely exposed; the articular ends are set free, and suitably rounded or shaped; the fascial flap is placed so as to cover completely the articular end of one or both bones involved, and stitched *in situ*; and then the wound is carefully closed. It is immobilized for a week or ten days, and then movements are commenced. The result in many cases is most gratifying, but, of course, all infective trouble must have ceased before the operation is undertaken, and absolute asepsis is essential if the fascial flap is to live.

Transplantation of joints has also been attempted in a few instances, but can scarcely be expected to be of much service in view of the successes of arthroplasty. *Excision* of joints for ankylosis is similarly placed on a fresh footing as a result of these facts At the *elbow* some form of excision will be frequently required, but will take on the form of an arthroplasty in the majority of cases. In the *knee* osseous ankylosis with deformity will frequently require the removal of a wedge-shaped fragment (cuneiform osteotomy) in order to overcome the displacement, but even then an arthroplastic element will be sometimes feasible. Where, however, the ankylosis is fibrous, arthroplasty will usually be practicable.

At the *hip-joint* ankylosis in a bad position is most commonly due to tuberculous disease, and, as already stated, arthroplasty is then not desirable. Most frequently the thigh is flexed on the pelvis and possibly adducted, the result being a most ungainly method of progression. In the majority of such cases it is unwise to attempt division of the cervix femoris (Adam's operation); it is too near the diseased area. Subtrochanteric osteotomy of the femur is the operation of choice; the bone is exposed from the side, and either chiselled across or divided by a Gigli saw. To put the limb in a good position, tenotomy of the adductors is usually required, and this is easily affected subcutaneously close to the pubes. The after-treatment must be sufficiently long to ensure sound and solid union of the bone, as the adductors are powerful, and can readily lead to displacement when the callus is soft. In non-tuberculous ankylosis of the hip the joint is best exposed by a large **U**-shaped incision with its base upwards, and the trochanter well within the **U**. This flap is raised, including the deep fascia. The base of the trochanter is chiselled across, the joint is exposed, and the head of the femur separated from the acetabulum and shaped up so as to move freely in the deepened and smooth socket. A flap of fascia is then carefully wrapped round the head of the femur and stitched in position. Divided ligaments are re-united; the trochanter is nailed back in position, and the wound closed. The limb is placed in a position of abduction with weight extension, and passive movements are commenced in ten days.

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* For further details, see J. B. Murphy, *Annals of Surgery*, May, 1912.

Hip-Joint Disease.

Although the term ' hip-joint disease ' is usually applied to a tuberculous arthritis, it is not the only affection involving this articulation, as rheumatic, gonorrhœal, or pyæmic affections are not very uncommon. Acute arthritis is also met with secondary to an acute infective osteomyelitis of the upper end of the femur, and is evidenced by all the ordinary signs of that affection, separation and necrosis of the upper epiphysis being a frequent result. Osteo-arthritis is frequently seen (p. 658), whilst Charcot's disease may also occur.

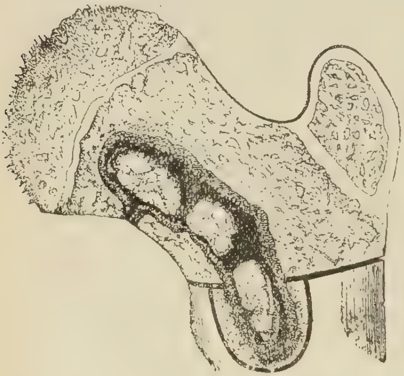

FIG. 328.—TUBERCULOUS DISEASE OF THE HEAD AND NECK OF THE FEMUR, SHOWING SEQUESTRA IN AN ABSCESS CAVITY, AND COMMUNICATION ON THE UNDER SIDE OF THE NECK WITH THE JOINT. (TILLMANNS.)

The epiphysis of the head has been invaded, and the articular cartilage entirely stripped off by the disease; the continuous black line indicates the amount of bone which it would be necessary to remove, if excision were undertaken.

Tuberculous Disease of the Hip (*Syn. :* **Morbus Coxæ, Tuberculous Coxitis, Coxalgia**) differs in no respect from the same disease as it affects other joints, and hence no detailed notice of the pathological anatomy is required. Suffice it to say that it may originate in the synovial membrane or bone, more frequently in the latter, and then commencing either beneath the articular cartilage or on the under side of the neck distal to the epiphyseal cartilage (Fig. 328). Very rarely the disease becomes circumscribed in the neck of the bone, forming a chronic abscess, the diagnosis of which is exceedingly difficult. More usually the disease spreads from the under side of the neck, and involves the synovial membrane, which passes into a state of pulpy degeneration. The substance of the epiphysis is invaded, and caries of the head is thereby produced, together with necrosis or ulceration of the cartilage (Fig. 314). The acetabulum undergoes similar changes; from the contact and backward pressure of the diseased head the posterior acetabular margin is absorbed and the cavity extended, whilst at the same time a new rim of bone forms beneath the adjacent periosteum at a slightly higher level, thus giving rise to what is known as a 'travelling acetabulum' (Fig. 329). In this way the socket is increased both in size and depth, travelling backwards and upwards with the head of the bone towards the dorsum ilii. Other factors assisting in the displacement of the head of the bone are: the tonic action of the muscles, keeping the limb in a position of flexion, adduction and inversion, thereby causing a considerable portion of the head to project out of the acetabulum; and

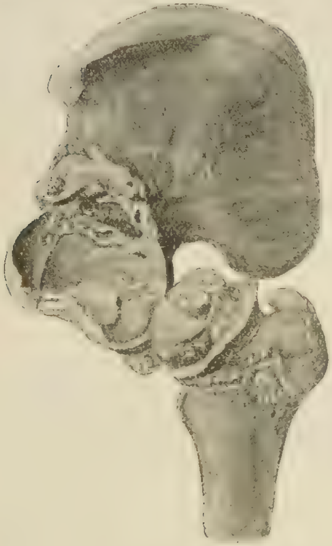

FIG. 329.—FEMUR AND ACETABULUM IN HIP DISEASE. (KING'S COLLEGE HOSPITAL MUSEUM.)

The epiphysis of the caput femoris has been practically destroyed, and the acetabulum is enlarged by absorption of its posterior margin and displaced upwards (*travelling acetabulum*). The rami of the ischium and pubes have been removed.

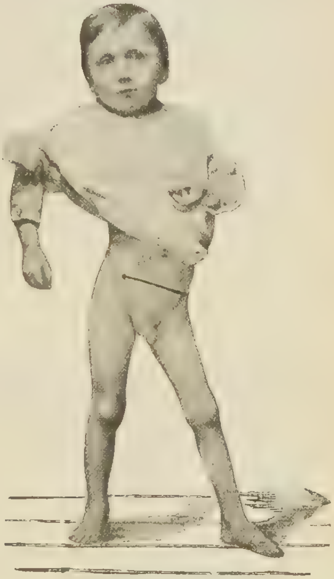

FIG. 330.—EARLY STAGE OF HIP DISEASE (LEFT SIDE) IN A CHILD. (FROM A PHOTOGRAPH.)

The black line is drawn from one anterior superior spine to the other, and shows not only the amount of abduction present, but also the tilting down of the pelvis on the affected side.

the early softening and destruction of the posterior ligaments, which are much thinner than those in front of the joint. Occasionally a mass of protuberant granulations sprouts up from the centre of the cavity, and may also assist in this process. Should the acetabulum be perforated, a tuberculous abscess is likely to form within the pelvis. The adjacent pelvic bones may either become thickened by the deposit of osteophytes, or carious; if a pyogenic infection is super-added, necrosis may supervene.

Clinical History.—The patient, usually a child, is observed to limp, and may complain of pain either in the hip or more often on the inner side of the knee, the latter being due to the fact that both joints are supplied by the same nerves—viz., the anterior crural, sciatic, and obturator trunks. There may be some history of injury, but not necessarily. On examining the limb in the *early stage*, it is usually found to be *apparently lengthened* (Fig. 330), whilst the thigh is slightly wasted. The nates are flattened, and the gluteal fold lost, conditions partly due to atrophy of the muscles, partly to the flexion of the limb. The joint is more or less rigid, and pain is produced on attempting to move it, or on jarring the leg, as by striking the heel or trochanter. The position assumed in this early stage is one of slight and increasing flexion, abduction, and eversion (Fig. 331, A), the reason for this being that thereby the ligaments, and especially the ilio-femoral, are most relaxed, and the capacity of the joint is at its greatest. The latter fact has been demonstrated in the healthy cadaver by inserting the nozzle of a syringe into the joint through the acetabulum, and forcibly injecting fluid, when this position is at once assumed. The flexion and abduction, however, are not always

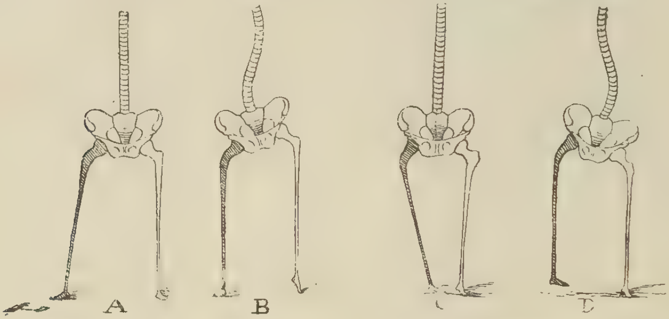

Fig. 331.—Diagram to illustrate the Positions Assumed by the Limb in the Early and Late Stages of Hip Disease.

A represents the position of abduction taken by the right limb in the early stage of hip disease, and B, Nature's method of masking this by tilting the pelvis down on the affected side, while the other leg is adducted; the effect of this on the spine, in causing a lateral deflection, is also indicated. C shows the same thing in the later stage, when adduction is present, and the pelvis is tilted upwards on the affected side, thus producing apparent shortening (D).

evident, since the flexion is masked by lordosis of the spine (Figs. 332 and 333), and the abduction by the pelvis being tilted down on the affected side, producing thereby apparent lengthening of the diseased limb and lateral curvature of the spine, with its lumbar convexity towards the affected side (Fig. 331, A and B). The sound leg being brought into a position of adduction, the parallelism of the limbs is maintained. The flexion can be demonstrated by any method which obliterates the lumbar curve of the spine, as by fully bending up the sound limb on the abdomen, the affected thigh rising at once from the bed and forming an angle which indicates the amount of flexion (Fig. 332). The abduction is demonstrated by laying a rod across the two anterior superior spines, and placing another at right angles to its centre. This will not correspond with the line of the body or of the limb, but makes an angle with it. The eversion cannot be masked. The rigidity is easily demonstrable in that all movements of the hip-joint are greatly limited; thus if an attempt is made to bend the affected thigh on the abdomen, the corresponding side of the pelvis is raised with it from the bed.

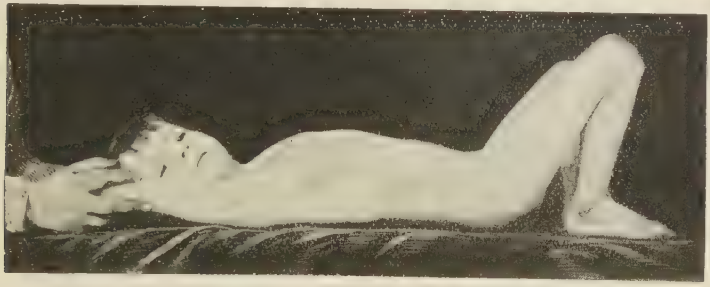

FIG. 332.—HIP DISEASE, WITH THE BACK FLAT ON THE COUCH, AND THE LEG FLEXED TO A CONSIDERABLE DEGREE.

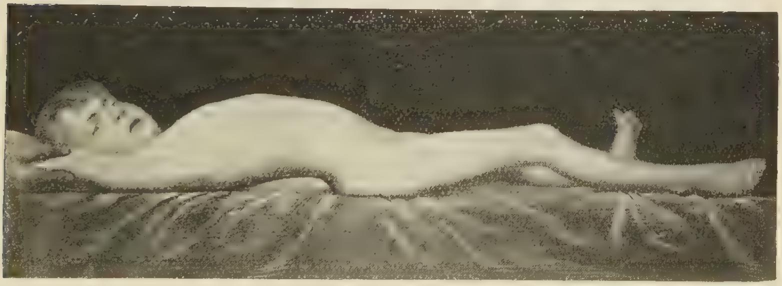

FIG. 333.—ON PRESSING DOWN THE DISEASED LIMB, THE SPINE BECOMES ARCHED (LORDOSIS) IN THE LUMBAR REGION, SO THAT THE HAND COULD BE READILY PASSED BELOW IT. THE EVERSION OF THE LIMB IS VERY EVIDENT.

As the disease progresses, and the bones become more extensively affected, the pain increases, with nocturnal startings, whilst abscesses form, and a certain amount of fever and constitutional disturbance is caused thereby. The position of the limb also changes; for although the flexion is maintained, and even increased, adduction and inversion are now associated with it. The pelvis is tilted up on the affected side (Fig. 331, C and D), causing *apparent shortening*, lateral curvature with a lumbar convexity to the sound side, and abduction of the healthy limb. No satisfactory cause for this position can be given, but it is usually attributed to the yielding of the posterior and outer part of the capsule, together with infiltration and weakening of the small external rotator muscles, allowing the adductors and internal rotators unopposed play.

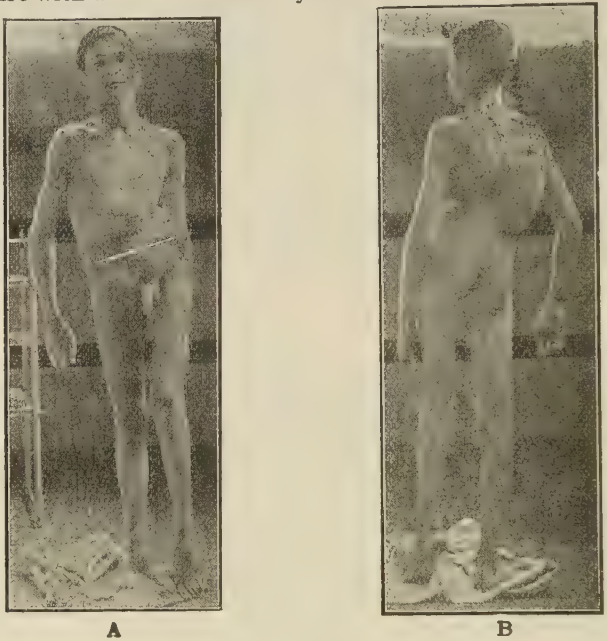

Fig. 334.—Position of the Limb in the Later Stages of Hip Disease.

In A a white line has been drawn between the two anterior superior spines to indicate the tilting of the pelvis upwards on the affected side necessitated by the adduction of the limb. Some amount of flexion was present, but this was not marked. In B the secondary curves of the spine are well seen.

When an abscess has formed, the most usual situation for it to point is a little in front of and internal to the great trochanter, close to the insertion of the tensor fasciæ femoris. It may reach that spot either from an opening in the anterior part of the capsule, coming thus to the surface along the line of least resistance, or it may burrow from the posterior portion of the capsule along the rotator muscles and superior gluteal nerve. Less frequently abscesses pass directly backwards to open in the gluteal region, or forwards along the pubo-femoral ligament, pointing on the inner side of the femoral vessels below Poupart's ligament. As a rare complication, the tuberculous process may extend to the bursa under the psoas tendon, which sometimes communicates with the joint, leading to the formation of an abscess in the upper part of Scarpa's triangle, and occasionally to a typical psoas abscess from extension upwards. An intra-pelvic abscess following perforation or disease of the acetabulum may either burrow upwards, and come to the surface above Poupart's ligament, or may gravitate downwards, and burst in the ischio-rectal fossa.

The final stage of the disease is one of *real shortening* (Fig. 334), due to erosion of the head of the bone and its displacement backwards upon the dorsum ilii. The position assumed is one of increased flexion, adduction, and inversion; whilst if suppurating sinuses persist, hectic fever and amyloid changes in the viscera are likely to follow.

At any stage cure by ankylosis may be obtained; but unless the abnormal position has been corrected by extension, deformity is almost certain to be present, whilst interference with growth may increase the shortening.

The **Diagnosis** of hip disease appears to be a matter of considerable difficulty to some, if we may argue from the mistakes which commonly occur. The pain in the knee present in the early stages leads to its frequently being mistaken and even treated for disease of that articulation; all cases of pain in the knee without apparent cause should suggest an examination of the hip-joint, as well as of the knee; a very slight amount of care in the examination should prevent such an error. From disease of the *opposite hip*, it is recognised by the relative mobility of the thighs on the two sides. The same test, viz., that of the mobility of the joint, should prevent congenital dislocation of the hip being mistaken for tuberculous disease, as is not unfrequent. The diagnosis from *sacro-iliac* disease is given at p. 678. *Spinal mischief* may also be confounded with it, if a psoas abscess points at any of the ordinary situations in which sinuses form in connection with the hip-joint. The presence of spinal deformity and the ability to perform the test movement for hip disease should readily enable the surgeon to make a correct diagnosis, but it must not be forgotten that the two conditions may co-exist. If the limb can be put into what is known as the tailor's position—that is, flexion to a right angle with marked abduction and eversion—one may be practically certain that hip disease is not present.

It is difficult to distinguish an *encapsuled abscess in the neck of the femur* from true hip disease. A constant deep boring pain is complained of, which is increased by pressure over the neck, or by jarring the trochanter; but if the limb is manipulated gently, it can be proved that the movements of the joint are not really impaired. Radiography is a useful aid in making a diagnosis of this condition.

It is often impossible to be certain as to the nature of the inflammatory attack following a *slight injury*. The patient is treated as for the graver affection, and if it gets well in a week or two, probably it is not tuberculous. Radiography is always of help in the diagnosis.

The **Prognosis** of hip disease is by no means unfavourable if the condition is properly treated. Of course, the patient is liable to develop acute tuberculosis or tuberculous disease elsewhere; or, if abscesses are allowed to become septic, serious complications—such as pyæmia, toxæmia, hectic and amyloid disease—may ensue. Apart from these, however, no serious consequences affecting life need be feared, although the usefulness of the limb may be seriously crippled from shortening or ankylosis, especially if the latter occurs in a faulty position.

The general **Treatment** of hip disease must be conducted along the same lines as for tuberculous lesions generally. In the *early stages* the limb must be kept at rest and deformity prevented. This is perhaps best accomplished by weight extension to the affected limb, and the application of a Liston's splint to the sound side; or the child may be fixed down by sandbags, or a Bryant's splint employed. For weight extension, the strapping must be carried well above the knee, and only enough weight used to keep the limb from painful starts. If the amount of flexion is slight, the limb may be allowed to lie on the bed in the horizontal posture; this will possibly induce some compensatory lordosis, but as the muscular spasm relaxes, the curvature of the spine disappears. When, however, a considerable degree of flexion is present, extension must be made along the axis of the flexed limb, which is supported on pillows. It will be found that after a few days the flexion diminishes, and the limb will then gradually assume the horizontal position. Should this precaution not be adopted, the extension merely produces lordosis, and the pain from intra-articular tension is increased thereby. When the more urgent symptoms have disappeared, as indicated by the absence of pain on the reduction or removal of the weight, a Thomas's hip-splint is applied, so as to enable the patient to get about (Fig. 335). This consists of a flat bar of malleable iron, about an inch and a half wide, extending from the lower part of the axilla nearly to the ankle; it is shaped so as to fit the varying curves of the body, and cross-pieces embrace the trunk at the level of the nipples, as also the thigh and the calf; it is firmly bandaged to the body and

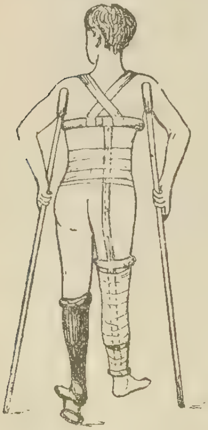

Fig. 335.—Thomas's Hip-Splint applied.

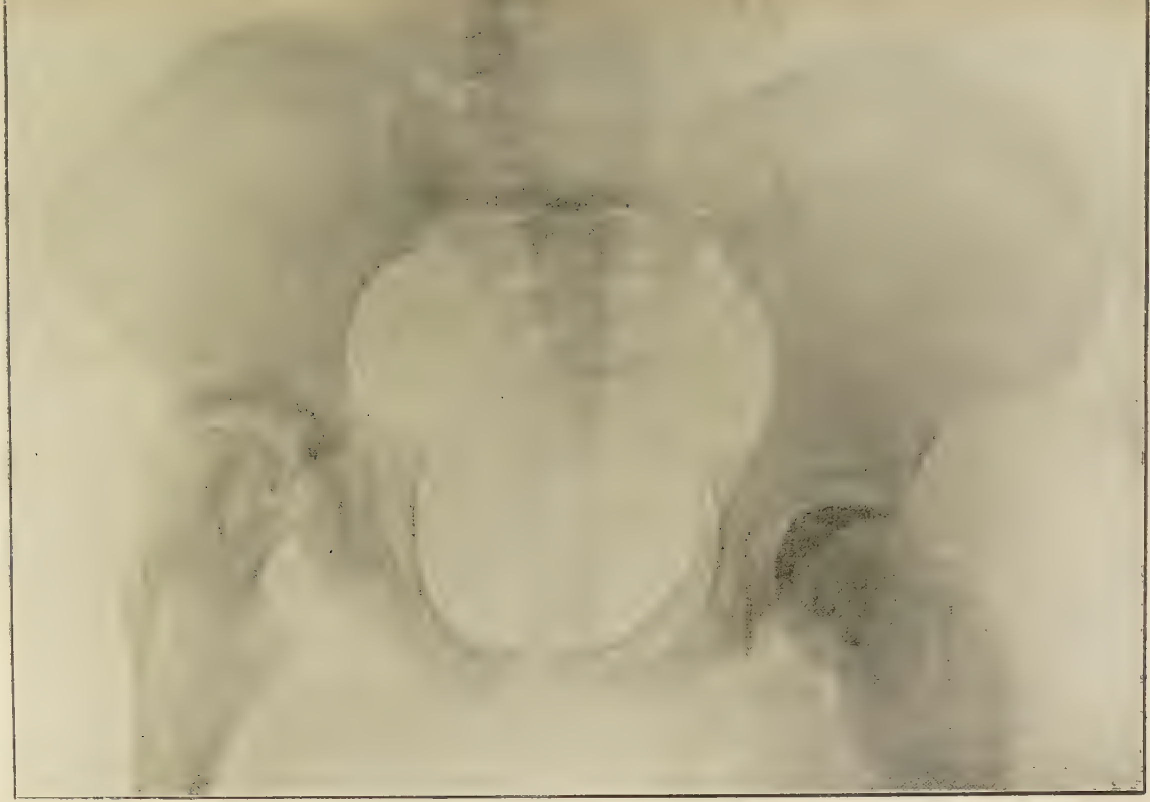

FIG. 336.—RADIOGRAM OF PELVIS, SHOWING TUBERCULOUS DISEASE OF RIGHT HIP-JOINT.

The head of the bone is displaced upwards, irregular in shape, and evidently invaded with granulation tissue. The acetabulum is similarly affected.

limb. A patten is placed under the boot of the sound leg, and the patient allowed to get about on crutches. This apparatus should be worn for at least six months after all signs of active disease have disappeared. It may also be employed in the earlier and more painful stages if it is at first bent so as to accommodate itself to the flexed position of the limb; as the effect of the rest becomes evident in a diminution of muscular spasm, the splint can gradually be straightened out, so that at length the limb is fully extended. In the case of very small children it is probably wise to put them in a Phelps's box (p. 714) for some months after the active manifestations have quieted down.

When abscesses form, they may be opened antiseptically, or preferably tapped and injected with iodoform, drainage if possible being avoided; of course, the former precautions as to rest and constitutional treatment are still maintained. More extensive operative measures, such as *excision* of the head, are nowadays seldom undertaken.

Many surgeons of large experience maintain that if suitable treatment is persisted in patiently for a sufficient time cure is almost certain to follow, and that therefore operations, other than tapping abscesses, are quite useless. *Per contra*, other eminent surgeons still consider that operation, even *excision* by the anterior method (p. 682), is justifiable and, indeed, advisable in many cases. Probably the truth lies halfway between these two opinions. If a case, in spite of rest and suitable hygienic measures, is not progressing satisfactorily, as shown by the persistence of pain, especially of starting pains at night, or by a raised temperature, or by the incidence of a local swelling, suggesting the formation of an abscess, and especially if radiography indicates the existence of a localized lesion, it is justifiable to cut down on the joint from the front and remove all the caseous débris, degenerated synovial membrane, and diseased cartilage and bone that can be reached without too great a disturbance of the parts. Sterilized iodoform is then rubbed in and the wound closed. In some cases a temporary dislocation of the head is justifiable, and then the acetabulum can be more effectively treated. The epiphyseal cartilage of the upper end of the femur should always be saved, if possible, so as not to interfere with the growth of the bone. Occasionally the mischief is so extensive as to necessitate the removal of the whole head; if so, the limb must be subsequently put up in a position of abduction, so as to prevent displacement upwards on the dorsum ilii and increased shortening at a later date.

In the *later stages*, when the case has been neglected and sinuses have formed in the gluteal region or behind the trochanter, *excision* by the *posterior* method is sometimes required; this is usually an easy matter, since the head is probably eroded and displaced. The sinuses should, if possible, be included in the incision, but under any circumstances must be opened up and scraped. When the acetabulum is extensively implicated, the disease can only be satisfactorily dealt with by removing the head of the bone, and the posterior method affords the best means of subsequent drainage; of course, this presumes that the general condition of the patient has not been seriously undermined, and that there is a good prospect of gaining a useful limb. Otherwise *amputation* through the hip-joint is required, especially when the mischief has extended into the pelvis, or when, after excision, a weak, flail-like limb results or osteo-myelitis supervenes. It is also needed when after excision sinuses persist and lead down into the acetabular cavity, from which there is a plentiful secretion of pus, and over the entrance to which the upper end of the femur is drawn, thereby obstructing the escape of the discharge, and rendering dressing both difficult and painful. The operation often gives most excellent results, the patient's condition rapidly improving. Removal by the anterior racquet method is perhaps the most convenient, in that the division and ligature of the vessels can sometimes be accomplished through a separate incision, or at any rate at a spot where drainage is most complete, and infection least likely to occur. Happily, amputation for hip disease, and even the posterior type of excision, are at the present time extremely rare operations.

Disease of the Sacro-iliac Joint.

Tuberculous disease of this joint is most commonly met with in adults, but rarely in children. It may commence in the synovial membrane, but is frequently the result of mischief starting in the pelvic bones, especially the ilium. The **Pathological Anatomy** calls for no description, inasmuch as it follows the ordinary course of tuberculous disease.

The **Clinical Signs** consist of pain and a sense of weakness in the lower part of the back, increased by standing, walking, or any movement—such as coughing, sneezing, and the like—which calls the flat abdominal muscles into sudden action and drags on the ilium. It is of a very unpleasant character, a sensation as if the pelvis were coming to pieces being experienced by the unfortunate individual. Owing to the fact that the lumbo-sacral cord passes in front of the articulation, pain is often referred to the gluteal region or down the leg. Movements of the limb cause pain if the pelvis is not supported, but can be freely performed if the pelvis is steadied. Compression together of the innominate bones, or their forcible separation, is the means of demonstrating most effectually the existence and situation of the pain. The patient is unable to stand or to put any weight on the affected limb, and hence limps during walking, allowing his body to lean forwards, and making use of a stick. There is apparent lengthening on the affected side, but on measurement from the anterior superior spine to the internal malleolus the leg is found to be of the same length as its fellow. This appearance is due to the fact that the whole innominate bone is tilted downwards and forwards, so that the anterior superior spine is at a lower level and more prominent than that on the opposite side. The region of the synchondrosis is often swollen, puffy, and tender; whilst after a time abscesses form, which may either point immediately over the articulation, or burrow upwards into the lumbar region, or forwards into the iliac fossa, or downwards into the pelvis, opening perhaps in the ischio-rectal fossa. The last is a most serious complication, since it is almost certain to introduce a pyogenic element.

The **Diagnosis** needs to be made from sciatica, hip disease, spinal disease, and some other sources of pelvic pain. *Sciatica* is known by the character of the pain, which shoots down the back of the thigh in the course of the great sciatic nerve, which may be distinctly tender on pressure. There is no apparent elongation of the limb, and compression together of the pelvic crests is painless. From affections of the *hip-joint*, sacro-iliac disease is recognised by the fact that, if the pelvis is supported, the thigh may be moved in all directions without great discomfort; whilst compression of the pelvis in hip disease causes no pain. Moreover, in the advanced stages of hip disease there is apparent or real shortening and deformity, conditions never noticed in the sacro-iliac affection. From *spinal disease*, the diagnosis should not be difficult if a careful examination of the spine and pelvis is made. When pain is the most marked symptom, the surgeon must exclude other possible sources—*e.g.*, rectal or uterine carcinoma; it is a useful rule to remember that in all such cases a rectal or vaginal examination should be made. It is quite possible in certain cases of sacro-iliac disease to detect a fulness on the anterior wall of the synchondrosis.

The **Prognosis** of sacro-iliac disease is not necessarily unfavourable if asepsis is maintained; the admission of pyogenic bacteria constitutes the main danger. In young women it may lead to subsequent deformity of the pelvis and trouble in parturition.

Treatment in the early stages consists in absolute rest in bed, with the application of a pelvic support, and attention to the general health. Abscesses may sometimes be dealt with in the usual conservative fashion—viz., by tapping and injection—but not infrequently it is necessary to lay them freely open, and deal with the diseased bone by scraping or gouging it away, allowing the wound to heal by granulation. Occasionally it is necessary to remove the posterior part of the iliac crest in the neighbourhood of the posterior superior spine in order to gain access to the diseased area; this may be accomplished by the chisel or trephine through a vertical incision, and excellent results often follow this proceeding.

Excision of Joints.

Excision of joints is an operation which is at the present time but little seen, except at examinations as a test of operative capacity; it has been rendered unnecessary in many cases owing to improved methods of treatment of injuries, and of the various inflammatory affections which involve joints. The conditions which necessitate excisions are mainly, though not entirely, due to neglect or incapacity, and even then the operative procedure described below must be modified suitably in view of the arthroplastic methods suggested above (p. 667). The chief articular lesions for which excision, partial or complete, has been recommended are as follows: (1) For various forms of injury in the neighbourhood of joints where ankylosis is likely to follow, and either interfere seriously with the utility of the joint or fix it in a bad position: the shoulder and elbow are the joints most frequently dealt with in this way; (2) for some forms of congenital or old-standing dislocation which cannot be otherwise remedied; (3) in the later stages of acute arthritis to prevent ankylosis; (4) in tuberculous arthritis, where conservative treatment has failed to cure the disease, or where it is advisable to deal with it in the earlier stages in order to shorten its course; (5) for ankylosis of certain joints, consecutive to arthritis, especially if in a bad position; (6) for osteo-arthritis in special regions.

The results to be attained necessarily vary in the different joints, and according to the particular cause. Sometimes ankylosis in a good position is all that can be expected, in others a freely moveable pseudarthrosis; in some cases the removal of certain diseased tissues is the primary object of the operation, whilst in others no disease is present. All these varying conditions must be taken into consideration in determining the nature and extent of any excision.

In a small text-book like this we must perforce limit ourselves to a description of the methods most commonly adopted, and refer students to special works on Operative Surgery for further details.

Shoulder.—The patient lies on the back, the shoulder projecting somewhat over the edge of the table, and with a sandbag beneath the scapula to steady it. The arm being slightly rotated inwards, an incision is made from a point midway between the coracoid process and the acromion, extending downwards and outwards for 3 or 4 inches through the fibres of the deltoid muscle (Fig. 337, D). It is better to incise the deltoid than to pass between it and the pectoralis major, the cephalic vein and accompanying artery being thus uninjured. The wound is thoroughly opened up by means of retractors, and the bicipital groove looked for; an incision is made along its outer border, and the long tendon of the biceps, if still present, turned out, and held to the inner side by a blunt hook. A twig of the anterior circumflex artery will here be divided, and need a ligature. The arm is now thoroughly everted, and the tendon of the subscapularis and the anterior part of the capsule, with which it is incorporated, freely divided; where practicable, the attachments of the muscle to the bone should be separated subperiosteally, a proceeding presenting no difficulty where inflammation has previously existed. The arm is now inverted and held downwards by the side of the table, so as to bring the great tuberosity into view; the muscles attached to this process are dealt with in a similar way, and the upper part of the capsule freely opened. The head of the bone is then protruded into the wound, and removed by the saw. It will often suffice to apply the saw obliquely through the substance of the tuberosity; this is to be preferred to removal of the whole tuberosity by a horizontal incision at a lower level. The synovial membrane and glenoid cavity are dealt with as circumstances may dictate, and it is often advisable to make a counter-opening through the posterior axillary fold for the insertion of a drainage-tube; the anterior wound can then be entirely closed. In applying the dressing, care must be taken to put a good pad in the axilla, so as to keep the arm from being drawn forcibly inwards by the muscles attached to the bicipital groove. There is no need to commence passive movements before the end of the first week. Fibrous union usually results, and the movements of the shoulder are generally very good, with the possible exception of abduction.

Excision of the Elbow may be required for simple or compound fracture-dislocation, or for subsequent ankylosis, especially if the limb is in a bad position, for tuberculous arthritis, and possibly in the later stages of acute arthritis. The best plan of operating is as follows: A single longitudinal incision, 5 inches in length, is made in the middle line of the posterior aspect of the joint, extending for equal distances above and below the tip of the olecranon, and a little to the inner side. The limb is held across the patient's body, the surgeon standing on the affected side. The incision extends through the substance of the triceps down to the bone. The origin of the flexor carpi ulnaris and the inner half of the triceps tendon are detached, and the hollow between the olecranon and the internal condyle cleared, the knife being kept close to the bone, and the soft parts effectively retracted. By this means the ulnar nerve escapes injury, and, indeed, is often not seen at all. The internal lateral ligament should be divided, and the common origin of the flexors detached from the front of the inner condyle. The outer half of the joint is then dealt with in a similar way, the anconeus being divided close to its insertion to the ulna, the continuity of the triceps with the deep fascia covering it being also maintained. The origin of the extensor muscles is separated from the back of the outer condyle, and the external lateral ligament severed. The joint can now be freely opened by dividing any of the fibres of the posterior ligament which remain intact, and the denuded ends of the bones protruded from the wound. The lower end of the humerus is thoroughly cleared, and the articular surface removed, the section passing through the centre of the olecranon fossa. The olecranon, together with the upper articular surface of the coronoid process and the head of the radius, are next sawn off, care being taken to draw aside and protect the soft parts by retractors, especially those covering the ulnar nerve. The synovial

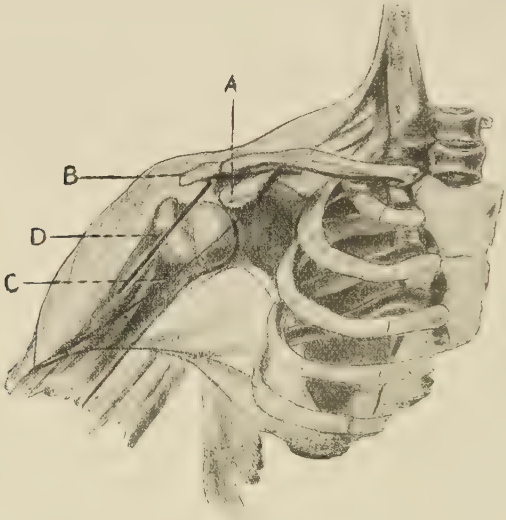

FIG. 337.—INCISION FOR EXCISION OF SHOULDER.

A, Coracoid process; B, tip of acromion; C, intermuscular line between deltoid and pectoralis major; D, incision.

membrane can be dealt with as may be necessary. Even if the head of the radius is free from disease, nothing is gained by leaving it intact, since ankylosis is very likely to follow unless plenty of bone is removed. As a general rule, a gap of 2½ inches should intervene between the divided ends of the bones. The wound is carefully sutured, and a drainage-tube inserted for a few hours. The limb is kept on a hinged angular splint for a week, by which time union of the external wound should be complete, but the position is altered each day. After a week, the splint may be dispensed with, and the limb kept at rest on a pillow, free passive movement, both angular and rotatory, being daily practised. Considerable attention is needed in order to obtain a good result, but in a successful case every movement of the joint is perfectly restored. As a rule, the lower end of the humerus develops two lateral bony processes, like malleoli, within the grasp of which the upper rounded ends of the radius and ulna are able to move.

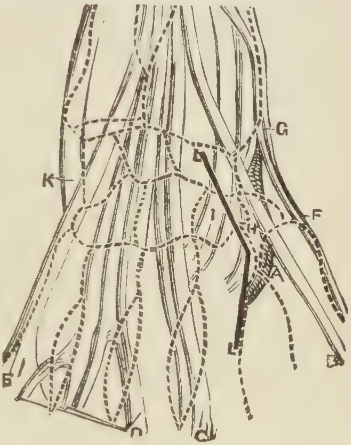

FIG. 338.—EXCISION OF THE WRIST (LISTER.)

A, Radial artery; B, extensor secundi internodii pollicis; C, ext. indicis; D, ext. communis digitorum; E, ext. minimi digiti; F, ext. primi internodii pollicis; G, ext. ossis metacarpi pollicis; H, ext. carpi radialis longior; I, ext. carpi radialis brevior; K, ext. carpi ulnaris; LL, line of radial incision.

The **Wrist-joint** is only excised for extensive tuberculous disease when abscesses and sinuses are present. Ankylosis of the articulation, though a troublesome condition, is not sufficiently so to require such treatment. The best method to employ is that known as Lister's operation, a somewhat complicated proceeding, but which in suitable cases gives excellent results. Prior to operating the fingers are bent, so as to break down any adhesions present. Two incisions are made, one on the radial side of the dorsum, and the other on the inner or ulnar aspect of the wrist. The dorsal incision is angular (Fig. 338, LL), commencing at a point on the back of the radius between the tendons of the extensor secundi internodii pollicis (B) and the extensor communis digitorum (D); it is at first parallel to the former tendon, and on its ulnar side, till it reaches the base of the second metacarpal bone, when its direction is changed, and it courses downwards along that bone for an inch or two. It should extend to the bone, and in doing so the tendons of the extensor carpi radialis longior and brevior (H and I) are divided as close to their attachments as possible. The tendinous structures are then stripped off the back of the dorsum on either side of the incision, and on the outer side a pair of cutting-pliers is insinuated so as to detach the trapezium from the rest of the carpus. The synovial sheaths of these tendons should, if possible, not be opened. The hand is then rolled over, and the ulnar incision made on the inner side of the limb, extending for at least 3 inches between the extensor and flexor carpi ulnaris tendons. The separation of the extensor tendons from the back of the carpus is now completed, and the attachment of the extensor carpi ulnaris (K) divided. The tissues on the palmar aspect of the joint are detached, the pisiform being severed from the rest of the carpus, and where possible left, and the hook of the unciform clipped off with cutting-pliers. The carpus is now free front and back, and the bones are either removed piecemeal or taken away *en bloc* by inserting a pair of cutting-pliers above and below, and dividing their upper and lower connections; more usually the carpal bones are picked out in fragments. Attention is then directed to the lower ends of the radius and ulna, and to the articular ends of the metacarpal bones, all the cartilage and the intervening synovial tissue being cleared away. Finally, the remaining fragments of the carpus are dealt with as the case may require. The radial incision may often be entirely closed, whilst a drainage-tube is inserted through the ulnar wound. The hand is placed on a special splint, with a thick convex cork support for the palm, which keeps the wrist slightly extended, and with a short lateral projection upon which the thumb can rest. The fingers must be flexed and extended daily, beginning on the second or third day, but the wrist should be kept at rest until it is quite firm. There is a much greater tendency to a flail-like joint than to undue fixity, owing to the amount of bone removed, and the necessary division of all the extensors of the carpus; if such occurs, a leather support must be worn, either as a temporary or permanent appliance.

The **Hip-joint** is rarely excised for conditions other than tuberculous disease, and even for this it is but seldom required. There are two chief methods of operating, the anterior and the posterior.

1. Excision by the *anterior method* is carried out as follows: The incision (Fig. 108, D; p. 336) extends from immediately below the anterior superior spine vertically downwards for 3 or 4 inches. It passes between the tensor fasciæ femoris and sartorius muscles superficially, and between the glutei and rectus deeply, a small arterial twig from the external circumflex being divided at this stage. The neck of the bone and capsule of the joint are exposed, and the latter is freely incised along its attachment to the anterior inter-trochanteric line, so as to allow of the admission of the finger, whereby the joint can be explored. The neck of the bone is cut through *in situ* by means of an Adams osteotomy saw, the incision through the bone being placed obliquely downwards and inwards. The head of the bone is now either prised out of the acetabulum by an elevator, or grasped by lion forceps and twisted out, a matter easily accomplished where the articular structures are diseased, but a proceeding of some difficulty in the normal joint of a cadaver. As much of the infected synovial membrane as possible is clipped away with scissors, and the acetabulum scraped, if necessary. The external wound is either closed, with the exception of an opening for a drainage-tube, or packed with gauze soaked in iodoform emulsion. The limb is put up in a position of abduction so as to keep the neck of the bone in the acetabulum.

2. Excision by the *posterior method* is at the present day so seldom required that it seems unnecessary to describe it here (p. 676).

The **Knee-joint** is excised for tuberculous disease, osteo-arthritis, or deformity due to osseous or fibrous ankylosis in a bad position. A horse-shoe-shaped incision is made, extending from the back of one condyle to the other, reaching downwards nearly as far as the tubercle of the tibia. The limb is flexed, the ligamentum patellæ divided, and the joint opened. The skin and subcutaneous tissues are then separated from the anterior surface of the patella, which may be at once removed by a curved incision above it, communicating on either side with that already made below, the subcrureal pouch of synovial membrane being also removed during this dissection. The flexion is now increased, and the lateral ligaments divided; by this means the interior of the joint is exposed, so that the attachments of the crucial ligaments to the tibia can also be severed. The lower end of the femur is then cleared of diseased synovial membrane, so as to allow of the application of a broad excision saw. The usual rule given as to the direction of the saw-cut in the bone is that the exposed bony surface left after removing its articular end should be absolutely horizontal, supposing the patient to be standing upright; some surgeons prefer to make the sections so that the limb shall be left very slightly flexed and in-kneed, a position which greatly adds to the subsequent comfort of the patient. To accomplish this the saw must be applied parallel to the articular surface—*i.e.*, at right angles to the axis of the body, not of the femur, and with a slight upward slant from before backwards. The bone should be partially sawn through by a side-to-side movement, but the posterior surface of the condyles should be divided by raising or depressing the handle of the instrument, so that the structures lying behind in the intercondyloid notch are not encroached upon. Sufficient bone should be sawn off in the adult to include the greater part of the articular cartilage, but as little as possible consistent with removing all the disease, otherwise the limb is shortened to such an extent as to interfere with its subsequent usefulness. The head of the tibia is then protruded, and cleared from the neighbouring soft parts; it is held absolutely vertical, and a saw applied in a horizontal position, the bone being divided from before backwards. All diseased synovial membrane is dissected away, special attention being directed to the posterior aspect of the joint. Hæmostasis having been effected, the bones are fitted together, and, if considered advisable, secured in position by thick silver wire, nails, or screws; if wire is employed, it should be introduced horizontally through the bones from side to side rather than antero-posteriorly. A Gooch's splint is applied to the limb, and in this it remains until sound healing has occurred, after which an immovable case either of plaster of Paris or water-glass is kept on for eight or ten weeks.

The **Ankle-joint** is excised for tuberculous disease. Two incisions are made, an inner and an outer. The outer incision runs along the anterior border of the fibula and curves round the outer malleolus, being about 3 inches in length. The lower end of the fibula is exposed, and by preference subperiosteally. The external lateral ligament is split vertically, and separated from its attachments to the fibula, its continuity with the periosteum being, however, maintained. The fibula is then divided about 1 inch above the tip of the malleolus, and the latter process of bone removed. The periosteum and ligaments are separated as far as possible from the front and back of the bones. The inner incision is T-shaped, and is made along the inner surface of the tibia, with a short transverse cut at its lower end, which reaches just below the inner malleolus. The periosteum and internal lateral ligament are dealt with as on the outer side, and the front and back of the tibia are easily denuded. The inner malleolus is projected from the wound, and the lower end of the tibia removed by a keyhole saw, the dorsal structures being held aside by a retractor. The articular surface of the astragalus is sawn off from the outer wound, or, if advisable, the whole of the bone may be removed.

The above subperiosteal method of excision is probably the best that has been suggested. The greatest care should be taken not to open the sheaths of the tendons, and in dressing the wound the foot must be kept at right angles to the leg, and no lateral deviation permitted. As soon as possible it is encased in plaster of Paris, windows being left for dressing the wounds, if necessary.

In non-tuberculous cases a transverse incision extending from one malleolus to the other may be employed. Sutures are placed through the tendons above and below, and they are then divided; the anterior tibial nerve is similarly secured above and below before division, and the vessels are divided between ligatures. By opening the capsule a very free exposure of the joint surfaces is provided, permitting a very thorough excision. The divided tendons and nerve are carefully sutured together before closing the wound.

Excision of the **Astragalus** is sometimes required in the treatment of tuberculous disease of contiguous joints, as also in some cases of talipes and of fractures or dislocations of the bone. Many methods of operating have been described, but it may be accomplished through a single vertical incision over the front of the ankle, running parallel to the vessels and tendons, which are carefully avoided and stripped back from the dorsum by means of periosteal detachers, so that the upper surface of the astragalus can readily be reached. The astragalo-scaphoid joint and ankle are then freely opened, and the ligamentous and fascial connections on either side severed. The neck of the bone may with advantage be divided at this stage, and its head removed, so as to give access to the under surface and allow of the division of the strong interosseous ligament extending between the adjacent surfaces of the astragalus and os calcis. It may be possible to remove the rest of the bone in one fragment, but it is sometimes wiser to break it up with chisel or gouge, and take it away piecemeal.

CHAPTER XXIV.

INJURIES OF THE SPINE.

The spinal cord is protected from injury in a most complete and efficacious manner. (*a*) Its position between the bodies and the laminæ with the spinous processes arising therefrom is itself mechanically advantageous, since, whether the spine is forcibly flexed or extended, the cord remains midway between the points of chief compression or extension, and hence in a position of rest. (*b*) The buffer-like action of the intervertebral discs, and the varying curves of the column, serve to distribute some part of any force that reaches it. (*c*) There is ample space in the medullary canal, in which the cord with its membranes is slung by prolongations of dura mater around the issuing nerves, whilst the cord itself hangs loosely within the dura mater, suspended by the ligamenta denticulata, and surrounded by cerebro-spinal fluid. (*d*) The cord terminates, in an adult, at the lower border of the first lumbar vertebra, a spot well above the junction of the fixed base and the moveable upper part, a point where the effect of jars and wrenches is mainly felt. (*e*) Nature has, moreover, introduced a whole series of buffers and other means of preventing shock to the spine when a person falls on his feet—*e.g.*, the arches and elasticity of the foot, the changes in direction of the bones at each joint, the interarticular cartilages of the knee, etc.

The parts of the spine most exposed to injury are those where a fixed and moveable portion meet—*e.g.*, the dorsi-lumbar and the cervico-dorsal regions. Moreover, the upper part of the dorsal curve, which projects backwards, is relatively a weak spot, and fractures are not at all uncommon about the fourth dorsal vertebra. The close proximity of the head explains the frequency of lesions about the upper cervical region.

Sprains of the spine are very common accidents, a fact not to be wondered at, when its complicated muscular and ligamentous arrangements are considered. They are produced by any sudden or unexpected movements, such as falls, especially from horseback, railway accidents, and the like. The injury affects most frequently mobile parts of the spine—*e.g.*, the cervical and lumbar regions, and may be limited to either ligamentous or muscular structures, or may involve both. The resulting **Signs** are simply those of a severe but localized trauma—viz., pain, tenderness, and perhaps a little swelling or bruising; the subjective phenomena are much increased by movement, so that the spine is kept rigidly quiet. If only the muscles or interspinous ligaments are involved, no further consequences are likely to arise; but when the ligamenta subflava are lacerated and the spinal canal is thus opened, pressure symptoms may arise from blood finding its way into the canal outside the dura mater, leading possibly to a temporary or permanent paraplegia. Inflammation of the damaged fibrous tissues may extend to the meninges and cord, and cause organic disease. Moreover, in patients of a tuberculous temperament spinal caries may follow such injuries; syphilitic or malignant disease has also been known to ensue.

In the *cervical* region, sprains may occur as a result of severe blows on the head, causing rupture of the inter-transverse ligaments, and the displacement may be so great as to simulate dislocation. The head and neck are held immoveable and rigid, and there is often considerable loss of power, the patient being sometimes unable to lift the head spontaneously from the pillow. Sprains in the *lumbar* region are very common, both as a consequence of overlifting, when the quadratus lumborum is most likely to be affected, and as a result of railway injuries, when they are often associated with nervous symptoms (p. 695). The back is kept fixed and rigid, the patient being unable to turn or stoop without pain. Sometimes hæmaturia results from injuries in the lumbar region, arising from an associated contusion of the kidneys.

Treatment.—The patient should be kept at rest, and fomentations applied to the injured part. When the painful or inflammatory symptoms have disappeared, massage with stimulating liniments is needed. In the severer cases the individual should be kept in bed for six or eight weeks, and in the cervical region some form of mechanical support may be subsequently necessary. The appearance of inflammatory symptoms involving the meninges calls for even greater care; the patient should then be kept as much as possible in the prone position, and a spinal icebag applied. The onset of paraplegia, due either to hæmorrhage or inflammatory exudation, would raise the question of laminectomy (p. 698).

Penetrating Wounds of the Spine are, fortunately, uncommon in civil practice, being generally due to stabs with pointed instruments, such as bayonets, or to gunshot wounds. They occasionally result from falls, the unfortunate individual becoming impaled on area railings, branches of trees, etc. The **Symptoms** produced are: (*a*) those due to the wound in the soft parts, which may also involve the peritoneal and pleural cavities, or damage to some of the viscera; in the neck, the vertebral artery is exposed to injury from this type of accident, leading to serious hæmorrhage; (*b*) various forms of fracture, the cord being compressed by fragments of bone which have been driven inwards, or by extravasated blood; (*c*) those due to laying open the spinal membranes—*e.g.*, loss of cerebro-spinal fluid, which in itself might prove fatal by draining the cerebral cavity, and so causing pressure on the base of the brain, or at a later date may determine the patient's death by setting up diffuse septic meningitis (p. 694); and (*d*) those due to wounds of the spinal cord. The effects of a total transverse lesion at different levels of the spine are given at p. 696. Of course, the division of the cord may be only partial, or it may escape entirely, whilst nerve roots or trunks may be involved, and in the lumbar or sacral regions the cauda equina may be divided.

Treatment consists in exploring thoroughly the wound under an anæsthetic, removing foreign bodies or displaced fragments of bone. and attempting to render it aseptic. Wounds of the vertebral artery or other structures are dealt with *secundum artem*, and special attention is naturally given to the cord and its membranes. Should the dura mater have been opened, and the cord have escaped injury, an attempt may be made to close the wound in the meninges, and the patient should subsequently be kept in the prone position and with the head low, so as to prevent, as far as possible, the escape of cerebro-spinal fluid. If the cord itself is divided or lacerated, it is useless trying to unite it, since its function in conducting impulses from the brain downwards is inevitably destroyed. Where, however, the cauda equina has been injured, it is perfectly justifiable to lay open the spinal canal to a sufficient extent to expose the divided nerve trunks, and then to suture them.

Fractures of the Spine.—The spine may be broken as the result of (*a*) *direct violence*—*e.g.*, a fall on the back over some projecting body, such as a carpenter's bench or a railing, or a blow on the back with a heavy stone or with a swinging baulk of wood, or a gunshot wound. This type of accident may involve any part of the spine, and, excluding those arising from gunshot, is less frequent than the class next to be described. Of necessity, the spine breaks at the point struck; the posterior parts of the vertebræ are most likely to be damaged in this form of injury. (*b*) Fractures are also due to *indirect* violence, then usually occurring in the lower cervical or upper dorsal regions. They are caused by forcible flexion of the spine, as by a fall downwards with the head doubled up, or by taking a ' header ' in shallow water, or when a man, being driven under a bridge, omits to stoop, and so is caught between the arch and the cart, or sometimes by the fall of a heavy weight on the back of the neck. The spine may break across more or less cleanly at its weakest point, or the lesion may be limited to one or two bodies, which are crushed and broken. The latter type (compression fracture) is often limited to the bodies; the former usually involves injury to the cord.

Fractures of the spine may be divided into two main classes, according to whether or not they are complete—that is, according to whether the continuity of the column is destroyed or not.

(A) **Incomplete Fractures** may be met with in various forms, and are most frequently due to direct violence.

(i.) *Fractures of the Spinous Processes* rarely occur except in the lower cervical or dorsal regions. In the upper cervical region the spines are short and retracted to allow of extension of the head; whilst in the lumbar they are also short, but very strong. The fracture is almost always due to direct violence, and is characterized by the signs of a local trauma, together with great mobility, perhaps crepitus, and irregularity in the line of the spines. The broken fragment is occasionally much depressed, and may even cause paraplegia by being driven into the spinal canal.

(ii.) *Fracture of the Laminæ* is not an uncommon accident, always resulting from direct violence. If only one lamina is broken, the signs are not very distinct, and cord symptoms are rare. When both laminæ yield, the posterior part of the neural arch, carrying with it the spinous process, is very likely to be depressed to a sufficient extent to compress the cord and give rise to paraplegia. Crepitus is often obtainable, and a gap in the line of the spinous processes can usually be felt.

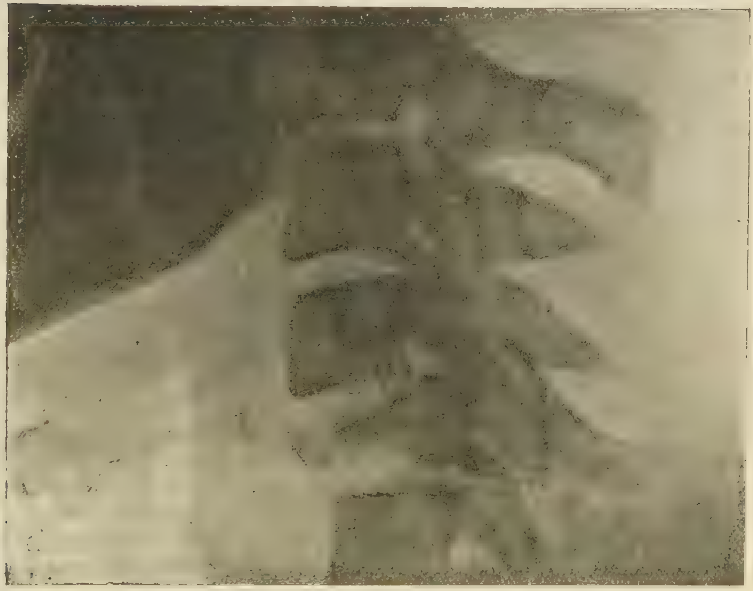

FIG. 339.—RADIOGRAM OF FRACTURE OF FIFTH CERVICAL VERTEBRA. (A. D. REID.)

The patient whilst walking in the street was struck to the ground by the fall of an outside shop-blind; the scalp was badly cut, and complete paraplegia from the sixth cervical nerve downwards was immediately evident. He lived for about thirty-six hours, and died in a condition of hyperpyrexia. In the radiogram the angle of the lower jaw and the hyoid bone are also visible.

(iii.) *Fracture of the Transverse Processes* is but rarely met with apart from other lesions of the spine.

(iv.) *Partial Fracture* through the bodies may occur in the form of fissures, which produce but little effect, except pain and rigidity, and cannot be diagnosed with certainty.

Even in fractures where displacement is not present, paraplegic symptoms may arise, either immediately from concussion of the spinal cord, or later on from the pressure of hæmorrhage or inflammatory effusions.

The **Treatment** merely consists in keeping the patient at rest for a time. The question of laminectomy for paraplegia, due either to displacement of the laminæ or to hæmorrhage, will be discussed later (p. 698).

(B) **Complete Fractures** are usually associated with displacement, and loss of continuity of the spinal column, and hence are often termed **Fracture-Dislocations.** They result either from direct or indirect violence, and are most common in the lower cervical or upper dorsal region. There is always a tolerably extensive lesion (Fig. 340); thus, the spinous processes and laminæ may or may not be fractured, the ligamenta interspinosa, supraspinosa, and subflava torn, the articular processes fractured in the lumbar and dorsal regions, or displaced without fracture in the cervical, and either the intervertebral substance torn across, or the bodies of one or two adjacent vertebræ broken, thus severing the spine into two halves. The upper or moveable portion is usually driven forwards over the lower or more fixed fragment, and impaction or comminution is often present. The spinal cord is compressed between the upper end of the lower fragment and the laminæ of the upper fragment, and although the displacement may be naturally remedied by the falling back of the bones into position (' recoil '), yet the effects of the crush on the cord are usually irremediable. In slighter cases the spinal membranes may be merely punctured by a splinter of bone, or hæmorrhage may occur either within the membranes, or outside them in the fatty theca vertebralis. Excessive indirect violence may lead to an associated fracture of the sternum.

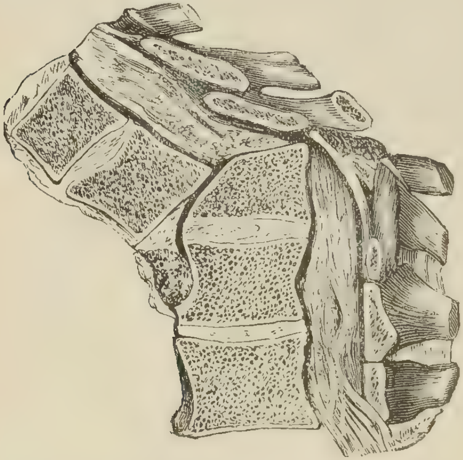

FIG. 340.—COMPLETE FRACTURE-DISLOCATION OF THE SPINE IN THE LOWER DORSAL REGION, WITH DISPLACEMENT AND COMPRESSION OF THE CORD. (AFTER KEEN AND WHITE.)

The **Signs** of a complete fracture are usually very evident, consisting of local pain, swelling, and bruising, and a certain amount of angular deformity, more or less according to circumstances. It may be possible to elicit crepitus, if the parts are not impacted, but all unnecessary movement should be avoided for fear of adding to the injury of the cord. Paraplegia below the part injured is present in most cases, and with it some amount of general shock. When the cord is disintegrated or divided, symptoms of spinal myelitis rapidly follow, and a fatal issue often occurs at an early date from toxæmia following septic cystitis or sloughing of the nates. The special phenomena of paraplegia are dealt with at p. 696. It may be stated here that lesions of the cervico-dorsal region in which the cord is extensively damaged are dangerous to life in that they cause paralysis of the muscles of respiration, with the exception of the diaphragm, and hence predispose to static pneumonia. Complete lesions at or above the level of the fourth cervical segment are usually fatal at once from paralysis of the phrenic nerve. The general mortality of fracture-dislocations of the spine is about 70 per cent.

The **Prognosis** of these cases turns largely on the situation of the injury and the amount of mischief sustained by the cord. The higher the lesion, the greater the danger, although patients with paraplegia from cervical fracture may live for years, and even partially recover, if the cord has not been totally disintegrated.

The **Treatment** naturally varies with the character of the case. The patient is carefully placed on a prepared bed, the greatest gentleness being used in handling and lifting him, for fear of increasing the damage to the cord. The bed must be firm, though not hard; perhaps the best type to employ is a horsehair mattress placed over fracture-boards; nothing more soft or yielding is permissible. Spring beds and wire-wove mattresses are most undesirable. A water-bed is required in the later stages, but should not be used at first, as it is scarcely firm enough. The shock resulting from the accident is treated in the usual way by warmth and, if need be, by stimulants; but it must be remembered that anæsthetic regions of the body can be easily blistered or burnt by hot-water bottles, unless carefully guarded by flannels. When reaction has occurred, a more thorough examination of the patient can be made, and the subsequent course of action decided on.

(*a*) In a small minority of the cases *operative treatment* is justifiable. The indications for laminectomy will be discussed subsequently (p. 698).

(*b*) When the displacement persists owing to impaction of the fragments, *reduction* under an anæsthetic may possibly be undertaken, provided that the lesion is not in the cervical region, and the paraplegia not complete. Of course, if other internal injuries are present which render the case hopeless, nothing should be done. Great care must be used in attempting reduction, since any undue violence may readily increase the mischief; in the lumbar region, however, considerable force may be employed without much danger. Whether reduction is accomplished or not, the further treatment must be directed in accordance with the indications given in the next paragraph. Where the surgeon fails to reduce the deformity, it may sometimes be advisable to make gradual weight extension from the feet or neck.

(*c*) In many cases, as soon as the patient is laid flat on a bed, the displacement remedies itself, especially if the spine has been comminuted, and then the treatment must be *symptomatic*, as also after reduction or operation, where the paraplegia persists or is only slowly recovered from. He is kept in bed, absolutely flat, and with the head low; perhaps some form of mechanical support—*e.g.*, a plaster of Paris or leather jacket—may be considered advisable; but its application is always a matter of difficulty, and in the early stages it does but little good. Food is regularly administered, and at first must be light and readily assimilable.

The chief care of the attendants must be directed to the skin, bladder, and bowels. *Bedsores* are extremely liable to form on all points of pressure, and hence the nates and heels must be carefully guarded (p. 120). In turning the patient to attend to the nates, the body must be rolled over as a whole, and not merely the pelvis twisted. It will often be found advisable to have a divided mattress placed beneath the pelvis, so that one lateral segment may be removed at a time, and thus rotation of the body will not be needed. A bedpan can also be used in this way without disturbing the spine. When the *bladder* is paralyzed, the urine must be withdrawn by a catheter. One of the chief dangers that the patient runs is from the supervention of septic cystitis, and the extension of the inflammation upwards to the kidneys. This is always due to infection from without, and the greatest care must be taken to prevent it. The penis should be thoroughly purified, and the urethra well flushed out before passing an instrument in these cases; in the intervals between instrumentation the penis is wrapped in a dry sterile dressing. Only soft rubber catheters are employed, and these must be boiled before use, and lubricated with some sterile material. Should infection occur, the bladder is irrigated twice daily with some mild antiseptic, such as Condy's fluid, boric acid, boro-glyceride (1 in 20), or sanitas (1 in 20), whilst urotropine, salol or boric acid in 10-grain doses may be administered by the mouth thrice daily. Probably, in spite of all precautions, the condition will persist, and prove fatal from extension to the kidneys. Recognising this fact, it has been recommended by some authorities to allow the condition of distension with overflow to occur in order to avoid the passage of catheters; the urine is permitted to flow away into sterile flasks frequently changed. The *bowels* are always obstinately constipated, and must be opened either by purgatives or simple enemata.

Under such a régime the patient may gradually recover, but more often succumbs to chronic toxæmia or exhaustion. Occasionally he may live for a long time, although paralyzed, possibly developing some amount of reflex micturition, if the lumbar centres are not involved. Varying degrees of restoration of power in the lower limbs are observed.

Dislocations of the Spine can only occur in the cervical region. The reason for this depends partly on the greater fixity of the dorsal and lumbar vertebræ, and partly on the direction of their articular processes. In the cervical region these look mainly upwards and downwards, with a slight slope forwards and backwards, so that it is not difficult for one to slip over the other; in the dorsal and lumbar region they are placed nearly vertically, so that dislocation is impossible without a serious concurrent fracture.

Any part of the cervical region may be the seat of a dislocation. The *occiput* has been displaced from the *atlas* in a few cases, resulting in sudden death; but if incomplete, life has been prolonged for a few hours or days. Dislocation of the *atlas from the axis* has followed blows on the neck, or has been the cause of death in hanging, whilst the attempt to lift a struggling child by the head has sometimes led to this calamity. In almost all cases the odontoid process has been fractured or the transverse ligament torn, causing instant death from compression of the cord, owing to the head and atlas slipping forwards. Lateral displacement from rotation has also been observed, the cord symptoms then being of a milder type.

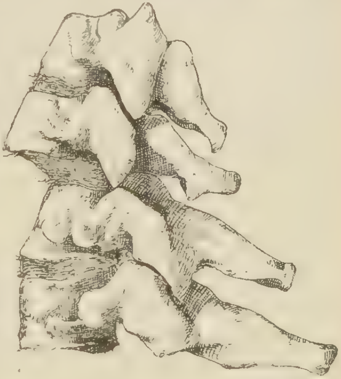

FIG. 341. — DISLOCATION OF THE CERVICAL SPINE. (COLLEGE OF SURGEONS' MUSEUM.)

The fifth cervical vertebra is displaced forwards, projecting in front of the sixth; the lower articular process of the fifth vertebra can be seen hitched in front of the upper articular process of the sixth, the body of which is slightly fissured.

Dislocation may occur between any two of the *lower five cervical vertebræ*, but perhaps most frequently between the fifth and sixth. It is most commonly unilateral, and almost invariably the result of forcible flexion of the head and neck, together with rotation. The head and upper portion of the spine are displaced forwards and twisted, so that the articular process of the upper vertebra involved slips over the front edge of the lower opposing articular process, and becomes caught by it so that it cannot return.

When the lesion is *unilateral*, the head is turned towards the opposite side, and more or less fixed, and the ear is raised. There is no evidence of compression of the cord, although tingling and neuralgic pains are caused by pressure upon and stretching of the nerve roots in the intervertebral notch. The spinous processes may be irregular and displaced laterally, whilst the line of the transverse processes is similarly altered. Such signs are, however, very difficult to make out in thick necks, and in consequence the condition is sometimes overlooked and left unreduced, giving rise to deformity, and permanent neuralgia may result. In early cases *replacement* may be accomplished. The patient is anæsthetized, the body fixed, and traction made upon the head and neck away from the side of the dislocation, so as to unlock the edges of the articular processes. Reduction may be effected with a definite snap or catch. In old-standing cases an operation may sometimes be attempted to relieve pressure on the nerves, but it is impossible to replace the bones.

If the condition is *bilateral* and complete (Fig. 341), there is a more serious involvement of ligaments, and the anterior displacement of the upper segment is such as to lead to grave pressure upon the cord and paraplegia. Occasionally, however, the lesion is only partial, and then the cord may escape without immediate injury, owing to the large size of the canal in this region, although hæmorrhage and inflammation may subsequently cause grave symptoms. *Treatment* is of but little avail in most of the cases of complete double dislocation, since probably the cord is irretrievably damaged; but when paraplegia is incomplete, it is possible that benefit may arise from early interference. Replacement by traction on the head with the neck flexed may be first carefully tried, and, failing that, laminectomy should be performed. After stripping the muscles from the bones, the surgeon will see the two cartilage-covered surfaces of the upper articular processes of the lower vertebra standing out clearly behind the laminæ of the displaced bone. Upward traction on the head may now again be made, and reduction thus attempted; but if this does not succeed, a small portion of the upper margins of the exposed articular processes is excised in order to allow of the unlocking of the bones. If the whole processes are removed, reduction is easier, but recurrence is certain, as it is impossible subsequently to fix the parts.

Affections of the Cord associated with Spinal Injuries.

Injuries of the spinal column are frequently associated with, or followed by, conditions affecting the cord and its membranes which may lead to the gravest results, even when the local lesion to the spine has been comparatively slight. These are frequently combined with one another in the most puzzling fashion, so that it is often difficult to state the exact nature of a certain group of symptoms; for simplicity's sake we shall discuss them here separately without attempting to describe the various combinations which may present themselves.

Direct Concussion.—This condition may be due to severe blows on the back, which do but little damage to the spinal column, or may be caused by accidents which lead to the infliction of greater mischief, but without any serious displacement of parts. There can be little doubt that the condition is due to the presence of minute extravasations in the cord rather than to its 'molecular shaking,' as was formerly supposed.

The **Symptoms** produced are those of loss of function of that portion of the cord situated below the point struck. The patient is usually prostrate from general shock to the system, and the reflexes are lost—at any rate for a time. Death may be caused at once by a blow in the cervical region, or varying degrees of loss of power and sensation may be produced in any or all of the limbs. In the lumbar and dorsal regions the patient complains of weakness of the legs, and loss of control over the sphincters. Priapism never occurs in simple concussion. The temperature of the body is depressed; the pulse is rapid and weak, and the respirations are shallow. The **Prognosis** is generally good, the patient recovering after a time; it is unusual for organic disease to follow.

In the **Treatment,** absolute rest to the spine is of the greatest importance, and this should be maintained if possible in the prone position, so as not only to diminish static congestion, but also to remove any pressure on the spine, and to allow topical applications to be made. A spinal icebag may be applied, or the back may be dry-cupped, whilst the patient is kept absolutely still, and on a low diet. The bladder and bowels may require attention, but no special drugs are necessary. Of course, local injuries require suitable treatment.

Spinal Hæmorrhage can here only be discussed as resulting from injuries. Apart from traumatism, it is interesting to note that, contrary to what happens in cerebral hæmorrhage, it occurs more frequently in young persons between the ages of ten and twenty than in old people. The bleeding may take place either into the cord itself or outside it, and hence the two following varieties are described:

(*a*) **Intramedullary Hæmorrhage,** or spinal apoplexy (*hæmatomyelia*), is usually met with in the lower cervical region, and results from some accident that causes acute flexion. Extravasation into the cord is rarely extensive, and may occur in the form of one clot, generally not larger than an almond, or more commonly in many spots, the grey matter being more or less ploughed up. The white matter is compressed, and sometimes the blood bursts through it into the subarachnoid space. Should the patient survive the injury for any length of time, secondary degenerations are established, and run the usual course. The patient is suddenly struck down with a more or less complete paraplegia, and with perhaps pain in the back, shooting round to the chest, and early followed by a rise in temperature. The paraplegia consists of a flaccid paralysis of the arms due to destruction of these centres and of the legs from interference with the descending columns. Some degree of recovery follows, especially in the legs, but the parts supplied from the damaged portion of grey matter—*i.e.*, the arms—are likely to remain paralyzed. In slighter cases only involving the grey matter, the arms alone may show signs of paralysis from the first. The *Diagnosis* of hæmorrhage turns on the rapid onset of paralytic symptoms without spinal irritation; fever may ensue for a few days, and if the cervical region is affected, extreme contraction of the pupil (myosis) may result from destruction of the cilio-spinal centre. There is retention of urine and fæces, and priapism is common. The *Prognosis* depends on the size and situation of the clot, a large clot producing more injury than a small one; hæmorrhage in the cervical region may be immediately fatal by interference with the respiration, whilst in the lumbar region it is unfavourable on account of the effect upon the sphincter centres. The outlook is best when the dorsal portion of the cord is affected. The *Treatment* is the same as was indicated for direct concussion, whilst the administration of a few doses of ergot may be beneficial.

(*b*) **Extramedullary Hæmorrhage** (*hæmatorachis*) is a more frequent complication of spinal injuries, such as sprains or limited fractures, than the former. The blood is usually extravasated between the bones and the dura mater, especially in the cervical region, but may occasionally be found within the dura. The symptoms are those of spinal irritation—*e.g.*, pain, hyperæsthesia, spasms, cramps, etc.—followed after a time by loss of power in the muscles supplied from the damaged area, or by 'gravitation paraplegia' (Thorburn), which gradually extends from below upwards, causing death by asphyxia, the whole series of phenomena being afebrile. In intramedullary hæmorrhage the symptoms of paralysis are more evident, and those of spinal irritation less marked. If a diagnosis can be made, ergotin may be injected in the hope of stopping the bleeding, and ice applied to the spine, or even laminectomy performed to relieve pressure; later on, prolonged rest and possibly the administration of some absorbent, such as iodolysin (p. 263), may cause the absorption of the clot.

Spinal Meningitis may spread downwards from the head, or commence as a local affection. Two forms are met with resulting from injury:

(*a*) In **Acute Spinal Meningitis** the inflammation mainly affects the arachnoid and pia mater (leptomeningitis). It is usually generalized in distribution, and not unfrequently extends to the cerebral membranes. It occasionally follows simple injuries, but is always infective in origin. *Pathologically*, it is evidenced by hyperæmia and loss of polish of all the membranes, with an abundant exudation; later on, lymph or even pus may collect, especially about the posterior surface of the cord; should the patient live, organization of the effused lymph may lead to extensive adhesions. *Clinically*, the disease is usually ushered in by a rigor, and runs a marked pyrexial course. The symptoms are: pain in the back, deep-seated, boring, and severe, increased on all movements, and often extending down the limbs or around the body; rigidity of the spine and limbs, accompanied by painful cramps and muscular spasms; extreme hyperæsthesia, especially of the legs, and increased reflex excitability; whilst rapid emaciation from pain and sleeplessness is soon produced. If the condition is limited to the spine, it is probably followed by signs of myelitis, viz., paraplegia, together with bedsores and vesical troubles, and these may lead to a fatal issue; cases, however, are met with which pass into a chronic state, and may more or less recover. If the process also involves the cerebral membranes, the symptoms of diffuse cerebral meningitis are also present, and the patient dies of coma. *Treatment.*—In simple cases an icebag should be applied to the spine, the patient remaining in the prone position. Ergot and belladonna may be given internally, and general measures to allay inflammation adopted. The bladder and rectum must be attended to, and bromides and chloral administered to gain sleep. Spinal puncture may be of some use.

(*b*) **Chronic Meningitis** is usually localized, and may involve either the arachnoid and pia mater (leptomeningitis), or be mainly limited to the dura mater (pachymeningitis). It may originate as a chronic affection, or is the sequela of an acute attack, and is more likely to supervene in syphilitic individuals. The membranes become thickened, and adhesions to the cord may occur; a chronic sclerosing myelitis is frequently associated with this affection. The *Symptoms* are those of localized pain and rigidity in the back, increased on all movements, and accompanied by shooting pains and hyperæsthesia, and perhaps muscular pains and cramps. The reflexes are usually exaggerated, and vesical complications may follow. *Treatment* consists in prolonged rest, with counter-irritation in the form of blisters or the button cautery applied to the back, whilst mercury and iodides are administered internally.

Spinal Myelitis may follow injuries of the spine, either as a direct consequence of depressed or displaced bone, or from hæmorrhage; it may also be caused at a later date by extension of inflammation from the meninges, or result from compression by lymph, pus, granulation or cicatricial tissue, or callus. It may be acute or chronic. In the former the cord becomes red and softened; the nerve elements are destroyed, and finally replaced by cicatricial tissue if the patient live long enough. In chronic cases the connective tissue becomes thickened, and the nerve structures compressed and disintegrated, whilst the meninges are always adherent and thickened.

Symptoms.—**Acute** myelitis is evidenced by the presence of pain in the back and along the course of the nerves arising from the inflamed area, soon followed by paraplegic symptoms, if these are not already present as the result of the injury. Slight irritative symptoms sometimes precede the paralysis. **Chronic** myelitis gives rise to a great variety of symptoms, but those most marked are a gradually increasing motor weakness, going on to paralysis, together with various sensory phenomena ending in anæsthesia, whilst there is trouble with the bladder and rectum.

The *treatment* of each of these conditions is mainly symptomatic.

Spinal, or Traumatic, Neurasthenia (*Syn.* : **Railway Spine**). Cases are not uncommonly met with in which, although there has been no direct injury to the spinal column or cord, and no immediate symptoms of importance, the fact is manifestly demonstrated in various ways that considerable commotion and disturbance have been produced in the nervous system. Railway accidents are the most common cause of this condition, but it may arise from any jar to the spinal column, or even after injuries to other parts of the body. The essential features are cerebral, and not spinal. The reason why railway accidents are so often responsible for this state is that the forces concerned are very great, and the collision unexpected, so that the muscles and ligaments are taken at a disadvantage, being off their guard, whilst the shock, terror, and mental disturbance are also important factors. Ligamentous and muscular lesions—*i.e.*, sprains and strains—are the usual local phenomena produced by such accidents.

In the majority of cases the symptoms are mainly due to excessive irritability and weakness of the spinal and cerebral centres, constituting a condition of nerve prostration, or **Neurasthenia,** and the history will usually be somewhat of this type: The individual at the time of the accident is thrown from side to side, or severely shaken, but does not lose consciousness, and, although feeling somewhat dazed, is able to alight without help, and may even assist others. He perhaps continues his journey, and goes to his business, but finds in the course of a few hours that his back is painful, his head aching, and that he cannot apply himself to his work. He returns home and goes to bed, sends for his doctor, who will probably prescribe rest and bromides. His condition remains for a time unaltered; he complains of pain and tenderness over certain regions of the spine, especially the lumbar, and is unable to walk, or to undertake any serious mental or physical effort, whilst all excessive sensory stimuli, such as a bright light or noise, are unusually disturbing. Neuralgia is often present; the pulse is weak; the urine may be retained or dribble away; sexual power is lost, and the temperature may be for a time subnormal. Accommodative asthenopia (or the inability to accommodate for near objects), resulting in a temporary condition of presbyopia, is also a marked feature in many of these cases. All the symptoms are aggravated by mental excitement and exertion, such as are produced by the necessary interviews with doctors and solicitors pending the financial compensation by the railway company. The immediate improvement which often follows the satisfactory settlement of his claim for damages is not necessarily due to imposture, but may result from the removal of mental tension and anxiety.

This condition of neurasthenia may develop immediately after the accident, as an acute condition, the patient lying helpless and prostrate, or more often chronically, as in the more common type of case described above. To it, however, is frequently added a considerable element of **Hysteria** in the form either of an acute attack of hysterics, or of a chronic unconscious exaggeration of the sensory symptoms. If the patient is examined in the supposed hyperæsthetic area whilst his attention is distracted, possibly no pain will be complained of.

The *Prognosis* is generally favourable, the patient recovering in time, but in a few instances permanent effects may be produced, or even a condition of chronic myelitis.

In the *Treatment*, a good deal of care is needed to judge rightly when the period has arrived for encouraging movement rather than rest, and thus to prevent the patient from developing a condition of chronic invalidism. Rest in bed is to be recommended at first, bromides given in moderation, and fomentations applied locally. Later on, friction with liniments and massage should be employed, and when all chance of secondary inflammatory disturbance is at an end, movement should be encouraged, and change of air advised, whilst a course of strychnine and iron may be administered.

Paraplegia has been mentioned so frequently in discussing the injuries of the spinal column and cord that a more detailed reference to it is essential.

Causes.—(1) It may arise as the direct result of the injury, and then is due to displacement of bone or hæmorrhage. (2) It comes on at a slightly later date as a consequence of extra-medullary hæmorrhage (localized or of the gravitation type), and that usually without pyrexial phenomena. (3) It may be due to the pressure of inflammatory exudate—*e.g.*, pus or lymph—and then is late in its development, and preceded by the pyrexia and irritative phenomena of that condition. (4) It may develop late in the case from the pressure of callus or cicatricial adhesions around the cord or its membranes (peri-pachymeningitis).

The **Phenomena**, whether due to injury or inflammation, are those of a total transverse lesion of the cord, absolutely destroying one segment. The following symptoms result:

1. Paralysis of the muscular area supplied by the destroyed segment, followed by rapid atrophy, reaction of degeneration, and loss of reflexes in this particular group of muscles.

2. Paralysis of all the muscles supplied by the segments below that which has been destroyed. The trophic condition remains normal, at any rate for a time, but when secondary descending degeneration in the antero-lateral columns has occurred, the muscles become contracted, tense, and rigid (late rigidity). The deep reflexes are entirely and permanently lost, but the superficial reflexes, though absent for a time, may reappear. If, however, a portion of the cord remains intact, both superficial and deep reflexes may persist or reappear, and even be exaggerated.

3. Complete anæsthesia of the sensitive area supplied by the destroyed segment, and of all the sensitive areas below, and loss of the muscular and thermal senses.

4. A narrow zone of hyperæsthesia is found at the upper level of the anæsthetic area, due to the irritation of the nerve roots at the site of injury.

5. Vasomotor paralysis combined with trophic disturbances in the parts which are paralyzed.

6. Visceral changes, especially in the bladder and rectum.

Phenomena of Paraplegia at Different Levels. 1. **At the Upper End of the Sacrum.**—Total transverse lesions at this spot are exceedingly rare; they only involve the cauda equina and cause paralysis of the sacral plexus. The effects produced are: (i.) Paralysis of all the muscles of the legs, except those supplied by the anterior crural, the obturator, and the superior gluteal nerves, whilst the perineal and penile muscles are also affected. (ii.) Anæsthesia of the penis, scrotum, perineum, lower half of the gluteal region, and the whole of the legs, except the front and outer parts of the thigh, which are supplied by the cutaneous branches of the anterior crural, and the region supplied by the long saphenous nerve. (iii.) The bladder and rectum are both shut off from their spinal centres, and hence there will be temporary retention of urine, followed by distension with overflow, and incontinence of fæces. The bladder, however, gradually contracts, its walls become thickened, and its capacity steadily diminishes, so that incontinence becomes more and more absolute.

2. If the lesion is situated in the **Dorsi-lumbar** region, or passes through the lumbar enlargement, which corresponds to the twelfth dorsal and first lumbar vertebræ, there is complete paralysis of the muscles of both limbs, including those passing to them from the trunk; total anæsthesia of the legs, gluteal and perineal regions, and possibly the lower part of the abdomen; whilst, if the vesical centres are destroyed, there is total paralysis of the bladder, with relaxation of the sphincter, dribbling of urine, which early becomes ammoniacal, and cystitis, due to trophic changes; if the centres escape, retention with overflow is the usual result; the rectum and sphincter ani are paralyzed, causing incontinence of fæces, the passage of which is unrecognised from the anæsthetic condition of the anus.

3. In the **Mid-dorsal** region the same phenomena are met with, but to them are added a more extensive region of anæsthesia, limited above by a hyperæsthetic zone, which feels like a tight painful girdle round the waist; paralysis of the flat abdominal muscles; and retention of urine, followed by distension with overflow. Occasionally, however, when asepsis is maintained, a condition of reflex micturition develops, in which the patient passes water unconsciously and involuntarily, whenever there is sufficient intravesical pressure to cause sensory stimuli to ascend to the undamaged centres. The abdominal paralysis is a most important addition to the gravity of the case, for all straining movements are thereby prevented, and thus coughing is embarrassed and defæcation hindered. The gases developing from the stagnant fæces accumulate and cause distension of the belly (meteorism), and thereby respiration may be seriously impaired. The diaphragm, moreover, is hampered in its action, since the lower ribs cannot be fixed or steadied, and hence its contractions tend to pull them inwards, instead of increasing the dimensions of the thoracic cavity.

4. In the **Cervico-dorsal** region all these phenomena are present, but the anæsthesia extends over nearly the whole trunk, and the hyperæsthesia may involve the arms, whilst the intercostal and spinal muscles are also paralyzed, and there is some weakness of the hand-grasp. Respiration has to be carried on by the hampered diaphragm, with the assistance of a few of the accessory respiratory muscles in the neck, and hence is much impeded; if bronchitis is present, it will prove fatal by asphyxia in a few days from the inability to expectorate. Priapism is a marked feature of cervical paraplegia, as also contraction of the pupil from interference with the lower cilio-spinal centre.

5. In the **Lower Cervical** region the arms also become involved in both the paralysis and anæsthesia, and the patient is likely to die in thirty-six to forty-eight hours, or less, in a condition of hyperpyrexia. If the lesion is situated at or above the fourth cervical vertebra, instant death results from paralysis of the phrenics and consequent stoppage of the respiration. If the fifth cervical segment is involved, the arms are usually found completely paralyzed, lying by the side of the trunk. A lesion through the sixth segment causes the arms

to be turned out and abducted, the elbows being flexed and the hands supinated with the fingers semiflexed. Injury to the seventh segment results in the hands being half-closed, the elbows bent, and the forearms lie in a condition of pronation over the chest.

Death from Paraplegia, therefore, may arise from a variety of causes and at various periods. It may be immediate, from respiratory failure in lesions above the fourth cervical vertebra; or it may occur from accumulation of mucus or pus in the air-passages, when the lesion is in the upper dorsal region; or it may be delayed for weeks, or even months, and then be due to sloughing of the nates, or septic absorption from an inflamed or ulcerated bladder, which is often associated with suppurative pyelonephritis.

The **Prognosis** and **Treatment** both depend on the position and character of the lesion causing the paraplegia, and on the previous habits and condition of health of the individual.

Laminectomy is an operation for the removal of the laminæ and spinous processes of one or more vertebræ, in order to relieve pressure on the cord, whether due to depressed bone, abscess, granulation tissue, excessive callus, cicatrices, or tumours. The operation consists in making a longitudinal incision in the middle line of the back, extending to the spinous processes; the muscular and tendinous structures are then cleared from the posterior aspect of the vertebræ as far as the transverse processes, a proceeding usually attended with considerable hæmorrhage, which can be checked, perhaps, better by hot sponge pressure than by attempting to secure the individual vessels. The neural arches are then examined for injury, etc., and those which seem to be most affected removed by cutting pliers, Hey's saw, or laminectomy forceps. The posterior aspect of the membranes of the spinal cord is thus exposed, and the various conditions which may be present are dealt with according to circumstances. In this place we have merely to consider the use of this operation after injury to the spine. For its employment in other conditions see Chapter XXV.

It must be remembered as a fundamental principle that repair is impossible after the spinal cord has been divided, or any one segment totally disintegrated, and hence, if it is certain that a total transverse lesion of the cord has been caused by an accident, it is absolutely useless to operate. Early and complete disappearance of all the reflexes is a suggestive phenomenon, but cannot be looked on as absolute evidence of a total transverse lesion; if, however, in addition to complete sensory and motor paralysis, the deep reflexes remain absent for any length of time, even though some of the superficial ones have reappeared, operation is useless. The presence of the deep reflexes is always an evidence that at any rate a portion of the cord remains uninjured, and would encourage one to operate. This question cannot, however, be absolutely settled in the early stages of the case, as it is at first impossible to say whether the symptoms are due to concussion, hæmorrhage, or bony pressure. Fortunately, delay does not appear to be so prejudicial to the patient's welfare as one might at first expect, and many cases are on record in which a good result was obtained even after months. One is therefore justified in waiting a while in doubtful cases. In spite of this, however, there will always be a certain number of patients in whom it is a matter of doubt as to whether or not any benefit will accrue from operation. The final decision under such circumstances depends on the special predilections and opinions of the surgeon, and the general state of the patient.

Apart from these doubtful cases, the following are generally admitted as being suitable for operation: (1) Penetrating wounds or fractures with displacement which involve the spine below the first lumbar vertebra; the cauda equina is present below that level, and not the spinal cord, and it is reasonable to treat it in the same way as one would treat a single peripheral nerve; (2) when the injury is mainly limited to the neural arch, which has been driven in by direct violence; (3) in all cases of bilateral dislocation of the cervical spine where the patient is not moribund; (4) if paraplegia arises with or without inflammatory symptoms, when an interval has elapsed since the accident; the pressure in such cases may be produced by blood or inflammatory exudations, and benefit may possibly arise from the operation; if, however, it is due to a total transverse myelitis, no good can follow. (5) When symptoms of irritation or paralysis supervene at a later date, from contraction of cicatrices around the cord or its membranes (peri-pachymeningitis), or from excessive callus formation, laminectomy may be performed with good hopes of a successful result.

CHAPTER XXV.

DISEASES OF THE SPINE.

Spina Bifida.

By **Spina Bifida** is meant a condition of imperfect development of some portion of the posterior aspect of the spine, with or without a similar affection of the spinal cord and membranes.

It must be remembered that the spinal cord is developed as a linear involution of the epiblast, the edges of this medullary groove growing up and uniting, so as to include a passage lined with epithelium, and subsequently known as the central canal. The cord is gradually separated from the overlying skin by an intrusion of mesoblastic elements, from which the vertebræ, together with the spinal muscles and ligaments, are developed. The ossification of each vertebra originates in three main centres—one for the body, and one for each half of the neural arch, whilst epiphyses are developed as plates above and below the body, as also for the transverse and spinous processes.

The following are the chief forms of spina bifida:

1. A **Myelocele** results from non-closure of the primitive medullary groove. It is characterized by the appearance in the lumbo-sacral region of a raw surface, which consists of the spread-out structures of the cord, at the upper part of which opens the central canal. The condition is incompatible with life, and the child, if not stillborn, as is usually the case, does not live beyond a day or two.

2. A **Meningocele** (Fig. 342) is characterized by a protrusion of the membranes, containing cerebro-spinal fluid, through a defect in the posterior walls of the vertebræ, the spinal cord and nerves being in their normal position. This variety is not very common.

3. A **Meningo-Myelocele** (Fig. 343) is due to a development of fluid within the membranes which remain adherent to the skin, the spinal cord or nerves of the cauda equina passing down the posterior aspect of the cavity as a strap, and the nerves traversing and perforating the sac to reach the intervertebral foramina.

4. A **Syringo-Myelocele** (Fig. 344) arises from a distension of the central canal of the cord, the posterior portion of which usually remains adherent to the skin, from which it has never been separated,

owing to defective development of the mesoblastic tissues. The spinal nerves travel round the walls of the cyst in order to find their way to the intervertebral foramina. Trophic phenomena are nearly always a prominent feature of these cases.

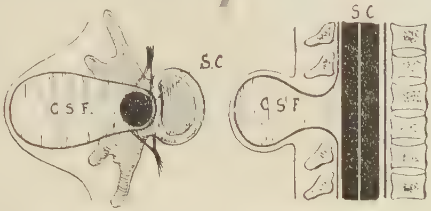

FIG. 342.—HORIZONTAL AND VERTICAL SECTIONS OF A SPINAL MENINGOCELE.

S.C., Spinal cord with nerves passing through the intervertebral foramina; C.S.F., sac filled with cerebro-spinal fluid.

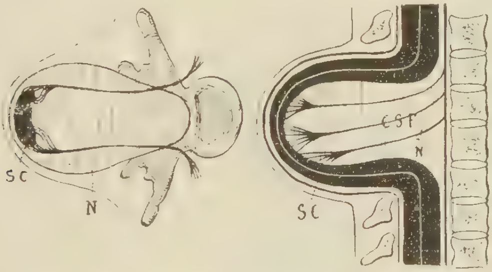

FIG. 343.—DIAGRAM OF MENINGO-MYELOCELE.

S.C., Spinal cord (black); C.S.F., sac filled with cerebro-spinal fluid; N, nerves crossing the sac.

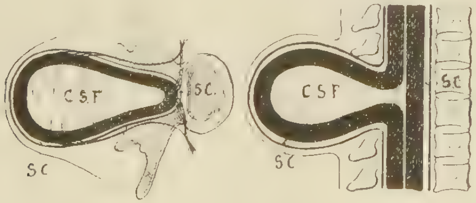

FIG. 344.—DIAGRAM OF SYRINGO-MYELOCELE.

S.C., Spinal cord with central canal dilated (C.S.F.) to form the sac; the cord has purposely been represented thick; it would really be thin, stretched, and atrophic. The nerves are represented passing round the sac.

Of these forms, the meningo-myelocele is that most frequently seen in living children although, according to Bland-Sutton, the first is really the most common.

Clinical Characters.—A spina bifida (except of the myelocele type) is recognised by the presence of an elastic swelling in the middle line of the back (Fig. 345), most commonly involving the lower part of the spine; it may be covered by normal skin, but usually that over the convexity is thin and translucent, and not unfrequently a number of small dilated vessels are seen coursing over it. On compressing this swelling, its size can sometimes be diminished, and then in infants distension of the anterior fontanelle may be felt, showing that the sac is filled with cerebro-spinal fluid; there is usually a distinct impulse on coughing or crying. The defect in the posterior portion of the vertebræ is often evident, the edges of the bones being felt at the margins of the swelling. Other deformities may be associated with spina bifida, especially hydrocephalus and paralytic talipes, in cases of syringomyelocele; perforating ulcer, ankylosis of phalanges, and other trophic phenomena, are also frequently developed at a later date.

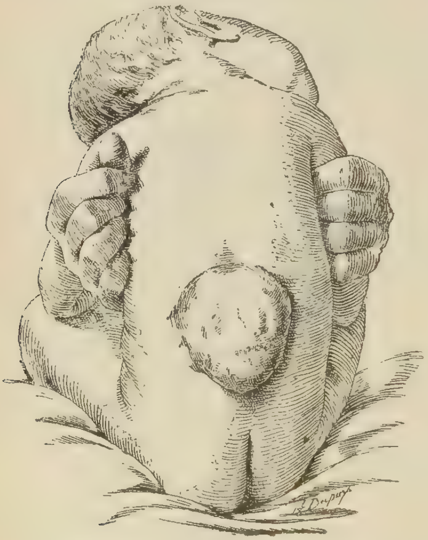

FIG. 345.—LUMBO-SACRAL SPINA BIFIDA OF THE MENINGO-MYELOCELE TYPE IN A BABY. (FROM A PHOTOGRAPH.)

The **Diagnosis** is usually evident, but sometimes in the cervical region a small tense meningocele is not readily recognised. Radiography may be of assistance in demonstrating the defects in the vertebræ.

The **Prognosis** of the case depends mainly on the thickness and character of the overlying skin. If it is thin and atrophic, as in many cases of meningomyelocele, the sac is likely to give way, causing death from sudden escape of cerebro-spinal fluid or from infective meningitis. If the spina bifida is small, and covered with healthy skin and subcutaneous tissue, the patient may reach adult life, but even then trophic phenomena may supervene, possibly as the result of the presence of foci of nævoid tissue, which have been known to develop in the canal when the cord is absent. Occasionally a meningocele, with only a small aperture of communication with the spinal canal, is cured spontaneously by the gradual growth of the bones constricting the neck of the sac.

Treatment.—Many cases are best left alone, the tumour being merely guarded from injury by the application of a suitable cap; but if the sac is gradually increasing in size and threatening to give way, surgical intervention is absolutely necessary if life is to be saved. Acupuncture through the thinned integument, the cerebro-spinal fluid being allowed to drain away subsequently into an antiseptic dressing, or tapping through the healthier integument around the base, repeated several times, and followed by compression, may lead to a cure in favourable cases. Better results, however, are obtained by tapping, followed by the injection of Morton's fluid (R. Iodi, grs. x.; pot. iod., grs. xxx.; glycerinum, ad ℥i.). A small quantity of the cerebro-spinal fluid is withdrawn, and then from half a drachm to a drachm of the iodine solution is introduced. It diffuses itself slowly, and its action is localized, so that if the child is kept quiet, and only semi-recumbent, its effect will be limited to the sac and its neighbourhood. In some cases persistent leakage may follow this treatment, and will need the application of a firm antiseptic compress; in many the injection needs to be repeated more than once.

Operative treatment is chiefly applicable in the meningocele type, and infants or those suffering from trophic phenomena do not stand it well. An incision is made over the sac, either in the middle line if the cord is not there, or to one side if it is. The child should be kept with the head low when the sac is opened, so as to limit, as far as possible, the loss of cerebro-spinal fluid. In a meningocele, the protruding membranes are cut away, after tying or suturing carefully the pedicle, and the spinal muscles drawn together by deep stitches, so as to create an extra protective barrier, in addition to the skin and subcutaneous tissues. When the cord runs down the back of the sac, it is freed by incisions on either side, and if it cannot be separated from the skin, the whole strip is replaced in the vertebral canal, the membranes are closed over it, and finally the muscles and skin are united by rows of sutures. The results obtained by this means in the treatment of meningoceles have been most encouraging

Spina Bifida Occulta is the term applied to a condition in which the posterior portion of the vertebræ is absent, but without any protrusion of the cord or its membranes. The overlying skin may be cicatricial in character, or a large growth of hair may arise from it; occasionally a lipoma develops in this situation, and by its growth compresses the spinal cord or drags upon it, and causes paraplegia. Unless such a condition is present, spina bifida occulta calls for no treatment, but an exploratory operation should always be undertaken when nervous phenomena supervene.

Congenital Sacral Tumours.

Other congenital conditions of the lower end of the spine are described as congenital sacral or coccygeal tumours. The majority of these arise from what is known to embryologists as the *neurenteric canal.* In early fœtal life the neural and alimentary canals are continuous, the passage of communication being known by the above name. Ordinarily, it disappears entirely after the union of the proctodeum with the intestine, but evidences of its existence are occasionally met with, either in the form of a cicatricial dimple adherent to the tip of the coccyx (*post-anal dimple*), or as one of the following conditions:

(i.) A *dermoid cyst*, containing the usual mixture of sebaceous material and epithelial cells, and often a tuft of hair; it develops in the space between the rectum and coccyx, and may either project below or by the side of the coccyx, or open into the rectum; the tuft of hair may then find its way out of the anus. In a case under the care of Mr. W. Turner, at Westminster Hospital, it was actually connected with the spinal meninges, removal involving the loss of cerebro-spinal fluid.

(ii.) A *congenital adenoma* of the post-anal gut is occasionally found in the same region. It is characterized microscopically by the existence of alveoli, lined by cuboidal epithelium, held together by connective tissue; it may attain a large size, but is quite innocent.

Various other tumours are met with in infants in this region, and the same title of congenital sacral or coccygeal tumour has sometimes been applied to them :

(*a*) A *spina bifida* of the meningocele type, which may communicate with the subdural space, or may have been shut off by a natural process of cure.

(*b*) A *lipoma* may also form here, and in some cases has simulated by its shape a caudal appendage.

(*c*) A partially-developed fœtus may be met with, enclosed within the subcutaneous tissues of the sacral region, and known as a *teratoma* (p. 228).

(*d*) *Sarcoma* and *cystic hygroma* have also been observed.

Inflammatory Affections of the Spine.

I. **Acute Osteomyelitis of the Spine** is uncommon. It usually affects the mobile portions of the spine in young people, and is due to the same causes as similar disease elsewhere—viz., auto-infection with pyogenic organisms after a slight injury. It is characterized by severe pain in a localized portion of the back, and fever, deformity is not a marked feature, since massive necrosis occurs, and not a gradually destructive caries. Abscesses form early, and there is great danger of an extension of the inflammation to the spinal meninges, leading to a fatal issue. The prognosis is extremely bad, owing to this latter complication, and the only possible treatment consists in early incisions to give exit to the pus. Sequestra can easily be removed from the back of vertebræ, but from the front only in the lumbar and cervical regions.

II. **Tuberculous Disease of the Spine or Spinal Caries** (*Syn.* : **Pott's Disease, Angular Curvature**).—The above names are applied to a tuberculous disease of the vertebræ, originating almost invariably in their bodies, which are more or less destroyed, leading to the so-called 'angular curvature.' It was first accurately described by Percival Pott in 1779.

The **Causes** are much the same as those of tuberculous affections elsewhere, and, indeed, it is often associated with other manifestations of the same disease. It most frequently occurs in children under the age of ten years, but may arise at any age, and equally in either sex. Any part of the spinal column may be involved, but the lower dorsal is by far the commonest. The cervical region is rarely attacked, except in children, whilst in adults the dorsi-lumbar vertebræ are the favourite seat.

Pathological History.—The disease commences either as a periostitis or an osteomyelitis. The *periosteal* variety is generally seen in adults, and is therefore the less common. It involves the anterior surface of one or more vertebræ, and is likely to spread under the anterior common ligament from one bone to another, whilst the intervertebral discs are also attacked and destroyed. The *endosteal* form is much the more common, and is almost invariably the type seen in children. The tubercle is deposited in the cancellous bone, possibly in relation with the plate-like epiphyses of the bodies, and produces its usual effect in softening and disintegrating the osseous tissue. The anterior parts of the bodies are affected more than the posterior, and hence deformity is common and nervous affections rare. The deformity produced is more or less of an angular type, due to the bodies falling together, either as a result of the weight of the trunk, or from muscular action, or when the patient has been in the recumbent position from the cicatricial contraction which is associated with the healing of the granulation masses in the front of the bodies of the bones. The disease spreads to adjacent vertebræ, either through the intervertebral discs which are destroyed in the process, or by extension under the anterior common ligament, when it may become widely diffused, body after body being eroded, and the cartilages suffering even more than the bones (Fig. 346).

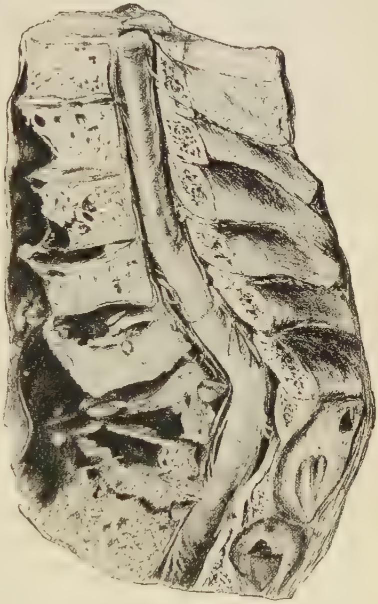

Fig. 346.—Tuberculous Disease of Spine, showing Destruction of the Bodies of the Vertebræ and Abscess Formation beneath the Anterior Common Ligament. (Modified from Specimen in College of Surgeons' Museum.)

In such a case the deformity produced is not angular, but rather of a general kyphotic nature. Occasionally, however, the disease starts simultaneously in many foci, so that the bodies of several vertebræ become pitted and carious, without producing general destruction. In other cases the process is limited to the bodies and intervertebral discs of two adjacent vertebræ, the periosteum being but little affected. This variety is, perhaps, most common in the lumbar region, where the bodies of the vertebræ are large and permit a limiting zone of sclerosed tissue to form; it is also not uncommon in this situation to find definite sequestra in adults (Fig. 347).

Cure is effected by the bodies of the vertebræ falling together and becoming ankylosed, so that a deformed and immobile condition of the diseased portion of the spine is often the best result that can be anticipated. The new bone thus formed becomes in time sclerosed and very dense, and the synostosis also involves the spines and laminæ. In favourable cases this occurs without suppuration, but not unfrequently abscesses form and add much to the gravity of the condition. Occasionally the tuberculous process extends backwards through the body of the bone, so as to implicate the posterior common ligament, and paralytic or other symptoms may then arise from pressure on the cord.

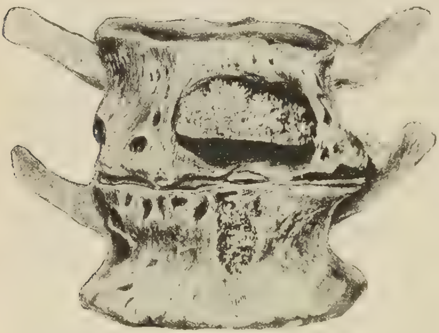

FIG. 347.—TUBERCULOUS DISEASE OF TWO LUMBAR VERTEBRÆ, SHOWING SEQUESTRUM ON THE ANTERIOR ASPECT, AND LATERAL THICKENING PREVENTING ANGULAR DEFORMITY. (COLLEGE OF SURGEONS' MUSEUM.)

Rare cases have been described in which the disease mainly affected the sides of the vertebræ, as a result of which lateral deformity occurred; still more uncommon are those in which the posterior portion of the neural arches is primarily involved.

In the upper cervical region the disease usually starts in the large joints, either between the occiput and atlas, or between the atlas and axis. For a time it may be limited to one side, but the body of the bone is attacked at an early stage, and the trouble then spreads to other joints. A special complication of this variety will be mentioned hereafter (p. 712).

The **Signs and Symptoms** produced by tuberculous caries of the vertebræ vary considerably in different situations, but for practical purposes may be described under the following five headings:

1. **Pain** is a constant and invariable accompaniment of the disease. although in the early stages it may not be specially prominent, being only elicited by careful examination. It is of two main types, the

local and the referred. *Local pain* is often not severe, but can usually be elicited by pressure or percussion over the spines, or perhaps more effectually by pressing upon the transverse processes, so as to induce rotation of the vertebral bodies one on another. Movements of the spine, bending or twisting, are similarly painful, whilst the same result can be brought about by jarring the spine, as by a blow on the head or nates. *Referred pain* is produced by pressure upon, or irritation of, the roots of the nerves as they emerge from the intervertebral foramina; consequently its distribution is governed by the arrangement of the nerve-root area of the affected spinal segment (p. 395). If the lumbar region is affected, the pain is referred down the legs; in the dorsi-lumbar region it may follow the last dorsal nerve, and be noticed in the lower part of the abdomen, or in the gluteal region; in the lower dorsal region pain is referred to the epigastrium, children who are unable to differentiate its precise nature complaining of ' belly-ache '; in the cervico-dorsal region the pain often extends into the arms.

2. **Rigidity** of the spine is a constant accompaniment of Pott's disease. In the *early* stages it results from muscular spasm, the object being to fix and immobilize the painful part. If the lower portion of the spine is involved, the back is held stiff and straight, the patient abstaining from all movements which would bend or stretch it. Thus, in order to pick up an object from the floor, the knees and hips are flexed, and the patient gradually lets himself down with an absolutely rigid back into a sitting or squatting posture; the body is raised in a similar manner by resting the hands upon the thighs, the patient, as it were, climbing with extended arms up his own legs. In a child rigidity in the dorsi-lumbar region can be demonstrated by laying him on his face, grasping the ankles, and ascertaining the amount of movement of the spine at that region by lifting the legs from the table, and also by moving them from side to side. In a healthy child the legs can be elevated, and the spine bent back in the dorsi-lumbar region, nearly to an angle of sixty degrees; whilst lateral mobility to the extent of thirty or forty degrees on either side of the median line is obtainable. When caries is present, neither of these movements can be made without including the thorax and dorsal spine. In cervical caries the patient steadies the head, and at the same time raises the shoulders by the help of the trapezius and sterno-mastoid muscles, whilst the chin is often supported by one hand, and the patient twists his whole body in order to look sideways.

In the *later* stages, when repair is taking place, or has occurred, rigidity of the spine is due to osseous ankylosis. After a cure has been established, compensatory movements of other portions of the spine mask, to a certain degree, the localized rigidity.

3. **Deformity** is necessarily present in almost all instances owing to the character of the reparative process. The amount of the deformity depends on many circumstances, and perhaps chiefly upon the number of vertebræ affected. Where only two bones are

involved, a true angular deformity may result, the body of the upper vertebra being welded to that of the lower, so as to produce a wedge-like mass, the surfaces of which are inclined to one another at an angle; compensatory curves of the spine above and below enable the patient to assume the erect posture. When a large number of vertebræ are affected, the curvature is never angular, but the whole region becomes bent forwards, and that sometimes very acutely (Fig. 348). In the lumbar region (and to a less extent in the cervical) loss of the normal forward convexity is often the most marked feature, the vertebræ being piled, as it were, one above the other, so as to constitute an absolutely vertical column (Fig. 350). When the affection is limited to two lumbar vertebræ, there is usually little or no displacement, the disease occupying the centres of the bones, so that the sides may escape altogether, and preserve the integrity of the spinal column; if a distinct projection of the spine is present, the portion of bone which appears most prominent is the spinous process of the lower vertebra. In the dorsal region the deformity is usually well marked, as several vertebræ are often involved; the length and obliquity of the spinous processes makes the posterior projection very considerable. In the cervical region there is rarely much deformity, owing to the small size of the vertebral bodies, but if several bones are involved, the head may be carried forwards and flexed, necessitating considerable compensatory changes in the dorsal, or even lumbar, regions. Lateral deviation simulating torticollis is also not uncommon.

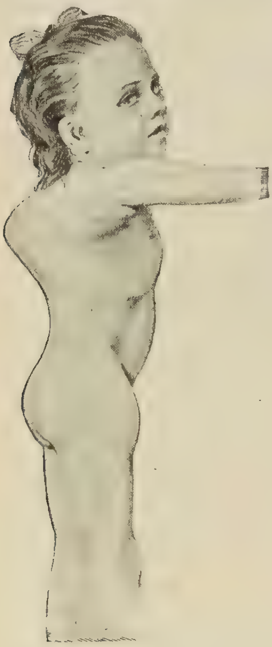

FIG. 348.—ADVANCED TUBERCULOUS DISEASE OF SPINE IN DORSAL REGION.

Secondary changes in the shape of the thorax necessarily accompany the more advanced cases of caries in the dorsal region, the sternum becoming convex anteriorly so as to compensate for the diminished vertical measurement of the thorax, and the ribs crowded together to such an extent as almost to obliterate the intercostal spaces. The lower floating ribs may, however, retain their normal position, and thus a horizontal groove may be produced corresponding to the line of the tenth rib. In such cases the patient becomes much stunted in growth and dwarfed, constituting the typical 'hunch-back.'

4. **Abscess** is the most serious result of spinal disease, for, owing to its deep origin, it often attains considerable dimensions before

it is recognised or treated, whilst it is usually impossible to deal with the causative lesion in the bones; if once the cavity becomes invaded by pyococci, an exceedingly grave complication is introduced into the case, which may even determine a fatal issue. It is relatively more common in adults than in children. The pus collects primarily on the anterior aspect of the vertebræ beneath the anterior common ligament (Fig. 346), which may be stripped from the bones for a considerable distance, owing to the tension within the abscess cavity. It thence finds its way to the sides of the bodies after perforating the ligament, and burrows in various directions, according to the portion of the spine involved.

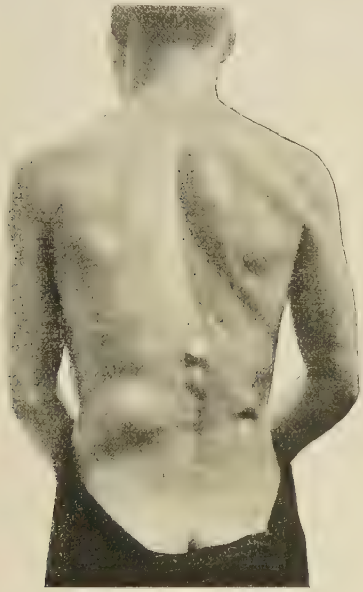

Fig. 349.—Lumbar Abscess arising from Tuberculous Disease of the Dorsi-Lumbar Spine.

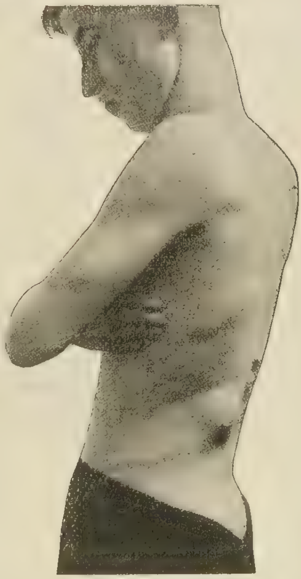

Fig. 350. — Lumbar Abscess. Lateral View of Same Patient.

The projection of the spinous processes is evident; the lateral curve is probably merely an associated or antecedent deformity.

In the cervical region a *chronic retro-pharyngeal abscess* is first formed; it pushes the posterior pharyngeal wall forwards, and may be detected from the mouth as an elastic fluctuating swelling, which, by its size, often leads to some difficulty in swallowing and breathing, whilst œdema of the glottis may be induced. Left to itself, it may burst into the pharynx, and suffocate the child, or at best pyococcal infection follows, and the osseous lesion is thereby aggravated. Not unfrequently the pus finds its way to the side of the neck, behind the vessels and sterno-mastoid, being guided to the posterior triangle by the prevertebral fascia, behind which it is situated. Less frequently it pierces this fascia, and presents in the anterior triangle, or travels down towards the mediastinum, or along the brachial nerves to the axilla.

In the dorsal region, the abscess starts in the same way in front of the vertebræ, and usually extends backwards between the vertebral ends of the ribs to form a *dorsal abscess*, which points 3 or 4 inches from the spinous processes, and has an impulse on coughing. Sometimes it extends further forwards, coming to the surface at the spot where the lateral cutaneous branches are given off. Tuberculous disease of the ribs, leading to caries or necrosis, or even a localized empyema, may be induced in such cases. In disease of the lower vertebræ, the abscess generally burrows downwards, passing under the ligamentum arcuatum internum of the diaphragm, thus entering the psoas sheath, and giving rise to a psoas abscess.

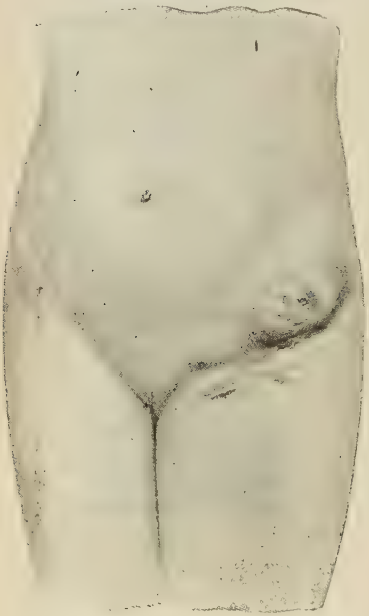

FIG. 351.—PSOAS ABSCESS POINTING IN THE ILIAC FOSSA, AND BURROWING AMONGST ADDUCTOR MUSCLES.

In disease of the dorsi-lumbar or lumbar regions, either a lumbar or a psoas abscess may result. A *lumbar abscess* (Fig. 349) is due to the passage backwards of the pus along the posterior branches of the lumbar vessels and nerves to the outer border of the erector spinæ, and usually presents superficially in Petit's triangle—*i.e.*, between the adjacent borders of the latissimus dorsi and external oblique muscles. It there forms a tense fluctuating swelling, with an impulse on coughing. A *psoas abscess* lies within the sheath of the psoas muscle, the pus being usually superficial to the muscular fibres, some of which are probably destroyed. It is often preceded by a condition of spasmodic contraction of the muscle with limited extension of the thigh, which may disappear after a period of rest. If it progresses, a resistant mass of a fusiform shape is at length felt, placed deeply in the abdomen; as it enlarges, it usually burrows outwards under the fascia iliaca to form a tense rounded swelling in the iliac fossa (Fig. 351). It thence travels under Poupart's ligament, behind and external to the common femoral vessels, being constricted at this spot so as to form a narrow neck. The sac then expands behind the common femoral sheath, the vessels being often displaced forwards, and the vein flattened out and compressed. Thence passing along the tendon of the ilio-psoas, to the neighbourhood of the lesser trochanter, the abscess usually burrows amongst the adductor muscles, forming a large swelling on the inner side of the thigh, and comes to the surface at or near the saphenous opening to the inner side of the main vessels, and hence may be mistaken for a femoral hernia. Occasionally the pus follows backwards along the internal circumflex artery, and may point behind the great trochanter; in other rare cases the abscess has been known to extend down the leg, and has even been evacuated by the side of the tendo Achillis. In a few instances the pus finds its way down into the pelvis instead of passing under Poupart's ligament, and then points in the ischio-rectal fossa, or possibly burrows through the sacrosciatic foramen.

In the most typical variety—viz., with a pouch both above and below Poupart's ligament, communicating by a narrow neck—the cavity is more or less shaped like an hourglass, and fluctuation can be detected in the lower pouch by compressing the upper, or *vice versa*. There is, of course, an impulse on coughing in the portion that projects below Poupart's ligament.

The constitutional disturbance associated with the formation of these abscesses is usually but slight, and there is no leucocytosis; perhaps there is a small rise of temperature at night, but if, as occasionally happens, ordinary pyogenic organisms find their way into the sac from within the body, this may become more marked. As the pus comes to the surface, considerable pain may be experienced from the tension and irritation of the soft parts, and fever of a hectic type is induced.

5. **Nervous Symptoms** occur in about one out of every thirteen cases of tuberculous caries of the spine, and then generally in bad or neglected cases. They are scarcely ever due to the acuteness of the curve, but have been known to result from fracture of the spine, the integrity of which had been weakened by the inflammatory process. The more usual cause is an extension backwards of the disease, so that a nodule or button of tuberculous material forms beneath the posterior common ligament, or pushes through it, compressing the cord against the laminæ, and actually invading the dura mater. Occasionally an abscess burrows backwards into the spinal canal and compresses the cord, and then the symptoms may be relieved by opening the abscess even at a distance.

The effect produced varies with the rapidity and acuteness of the process. When the pressure is rapidly developed, a subacute myelitis ensues; but more frequently it is of a chronic or sclerosing type. The cord is then found to be constricted or indented by the tuberculous mass, and perhaps considerably reduced in size; its texture is firmer than normal, and the colour grayish. The onset of symptoms may be suddenly induced by hæmorrhage or displacement of bone, but is more usually gradual. The dorsal region (about the eighth vertebra) is that most often involved, since there is plenty of space in the cervical region, and in the lumbar the cord has broken up into the cauda equina.

The symptoms arising from pressure on the cord must be distinguished from those due to irritation of, or pressure on, the nerve-roots. The latter causes neuralgic pain within the area of distribution of some nerve-root, possibly in the later stages associated with anæsthesia (*anæsthesia dolorosa*), or a limited motor weakness if the anterior roots are involved. In compression of the cord, motor phenomena are more evident than sensory, since the sensory track lies towards the centre of the cord, and so is more protected from injury. At first there is some dragging of the toes on walking, and loss of power in the legs, combined usually with neuralgia, weakness of the sphincters, and exaggeration of the reflexes; the muscles are sometimes in a condition of spastic contraction. Later on the paralysis becomes complete, and, as degeneration of the cord follows, secondary contractions and rigidity occur, and the reflexes diminish. Absolute incontinence sometimes supervenes, the bladder emptying itself periodically and involuntarily, or the urine trickling away continually from either a full or empty viscus.

Special mention must be made here of a grave complication only occurring in the upper cervical region, which may result in sudden death. Tuberculous disease of the upper two vertebræ usually originates in one or more of the large articulations on either side of the atlas; if these joints become disorganized, displacement may occur at any moment, and in this way the occiput slips forwards upon the atlas, and may lead to gradual or sudden compression of the cord and consequent death. The disease sometimes spreads to the body of the axis, and by this means the odontoid process becomes detached, or the transverse ligament gives way; in either case, the weight of the head carries the arch of the atlas forwards, and death ensues at once from compression of the medulla.

Course of the Case and Prognosis.—Left to itself, the disease usually progresses more or less steadily, the bone lesion becoming gradually more marked, and abscesses are likely to develop. If treated efficiently, and taken in hand early, repair by ankylosis may be confidently expected. Even when an abscess forms, prolonged rest may lead to its disappearance, the fluid part of the pus being absorbed, and the solid elements becoming inspissated and dry, forming a putty-like mass lying on the front of the vertebral column; this may subsequently undergo liquefaction, probably owing to infection with pyogenic cocci, constituting what is known as a *residual abscess*. Should, however, the abscess burst or be opened, and become septic, symptoms of chronic toxæmia supervene, and the patient is sooner or later exhausted by the discharge, and dies from asthenia. If dealt with judiciously, and sepsis avoided, the abscesses may be cured, and if at the same time the spine is kept at rest, and suitable hygienic measures are adopted, the lesion in the bones is able to consolidate. The onset of paraplegia must not be looked on as rendering the case hopeless, since with prolonged rest the paralytic phenomena often disappear entirely. Septic cystitis and bedsores may arise as complications, and, if allowed to progress, cause death. Occasionally, as a result of the implication of the spinal canal, diffuse meningitis follows, leading to a rapidly fatal termination. As in tuberculous disease elsewhere, the patient also runs the risk of acute miliary tuberculosis, whilst other organs —*e.g.*, the lungs, brain, or kidney—may become affected. In spite of these possibilities, however, the prognosis is good as regards life in cases free from complications, and where suitable treatment is practicable.

The **Diagnosis** of spinal caries is rarely a matter of difficulty when the characteristic deformity exists, but in the early stages, when the displacement is not evident, or if there is only a very slight prominence of the spinous processes, it is likely to be mistaken for a simple rachitic or statical curve; whilst if neuralgic pain is a prominent symptom, it may possibly be looked on as a case of spinal or intercostal neuralgia, or as rheumatism, or even be ascribed to renal affections. Tumours of the spine, such as cancer or hydatid cysts, syphilitic disease, and aneurismal erosion, also produce symptoms somewhat resembling those of spinal caries, and in adults it may be impossible from the local phenomena alone to determine which of these conditions is present, although a careful consideration of the general history and of the onset of the symptoms, and a radiographic examination, may throw light upon the case. Frequently the course of the disease and the reaction to treatment must be mainly relied on in forming a diagnosis. The spine should always be examined from before and from behind, and pain on pressure over the transverse processes and rigidity of the back are the symptoms on which most stress should be laid.

Local Treatment.—In order to promote the development of a suitable and sufficient synostosis, the great essential is absolute immobilization and freedom from weight-bearing. At the same time it is desirable that means should be taken to limit the degree of deformity. These objects may be effected in the following ways:

(*a*) *By the Adoption of the Recumbent Posture.*—The patient is kept in bed lying on his back without a pillow, and with sheets passing over the trunk and thighs, secured by sandbags on either side and between the legs. If thought necessary, extension by weight and pulley, as described at p. 534, may also be employed, together with extension of the head by a weight attached to a chin-strap and occipital band, which are united just above the ears. For children a weight of three pounds attached to each of these usually suffices to tire the muscles and prevent serious deformity. The child is kept lying down in this way for some months (probably six as a minimum), and certainly until the pain has ceased. It may then be possible to arrange for the application of a suitable jacket or brace, and in this the child may be allowed to walk about until the disease is absolutely cured.

(*b*) *The use of Phelps's Box* is specially valuable when treating children. The child is placed in a wooden box 6 inches deep (Fig. 352), the lower end of which is divided into two portions, one for each leg, a suitable aperture being left at the junction of the divided parts for the passage of the excreta. Careful padding is applied to the whole of the interior, and the child is strapped and bandaged into this apparatus (Fig. 353), and kept there for a period varying from six to twelve months. The whole trunk is thus immobilized, and the child can be carried about in his box, and taken into the open air. Extension can also be made, if necessary, by elastic accumulators attached to the head and neck, or legs. Various modifications of this plan of treatment have been suggested and practised, and measures can easily be arranged for keeping the body and spine hyper-extended, so as to limit the deformity. The ' back-door ' splint devised by Dr. Gauvain* is eminently suitable to achieve this purpose.

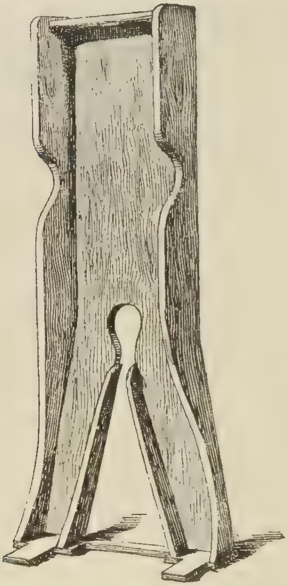

FIG. 352.—PHELPS'S BOX WITHOUT THE PADS.

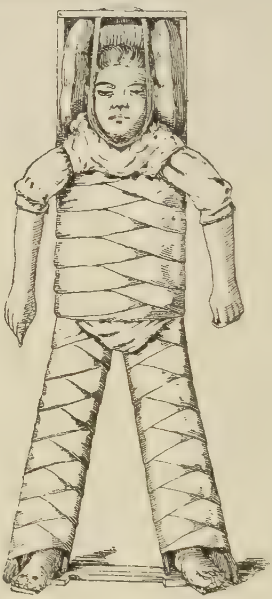

FIG. 353.—THE SAME WITH THE CHILD IN POSITION.

(*c*) In very young children perhaps the simplest apparatus is a double Thomas's splint, with a suitable crutch above to fix and support the head.

(*d*) *The Application of a Plaster Jacket* is desirable in children in the later stages of the disease, but in adults it may be used safely somewhat earlier, though *never in the acute stage*. If the disease exists in the dorsal region, the plaster jacket should extend from the axillæ to just below the iliac crests; if situated above the mid-dorsal region, the head must also be immobilized by the formation of a suitable collar (Fig. 354). The patient, who has been prepared as for an operation, is stripped to below the waist, and a closely knitted woollen vest fitted to the body, and fixed by straps passing over the shoulders. A woollen pad is placed beneath it over the abdomen to allow for distension after meals, and in women similar smaller pads may be placed over the mammæ to protect them. Coarse canvas bandages, into the meshes of which plaster of Paris has been rubbed, are thoroughly soaked in water, and then wound evenly round the body until a layer of five or six thicknesses is obtained. Over this a paste of plaster of Paris, prepared as described at p. 483, is laid, until the jacket has attained sufficient thickness and consistency, and before it is quite set it is carefully moulded to fit accurately to the pelvic ring, or to the chin and neck. It is allowed to dry before the patient's position is altered. If the disease is in the lumbar region, the jacket may be applied with the patient in the horizontal position; but above this the patient must be vertical, so as to extend the spine. This is best secured by suspending him by means of a bridle attached to the head in a tripod or gallows, and the toes may be allowed to touch the ground. The jacket may be reinforced to meet particular strains, and may subsequently be lightened by cutting out unnecessary portions. It must be worn until all pain and evidence of active disease have finally disappeared, and after that the patient should be fitted with a poroplastic support for a time.

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* Gauvain, *Lancet*, March 4, 1911.

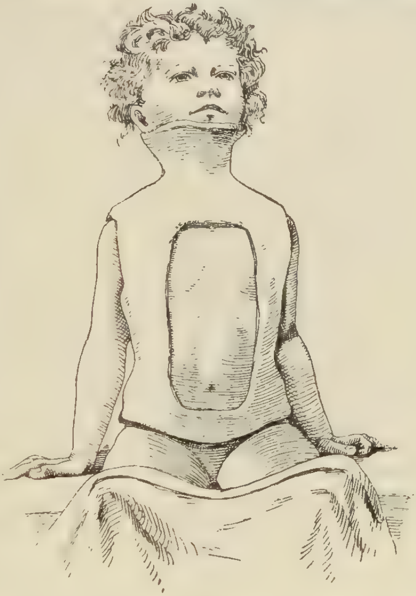
FIG. 354.—PLASTER JACKET APPLIED FOR TUBERCULOUS CARIES OF UPPER DORSAL SPINE, ILLUSTRATING FIXATION OF THE HEAD AND NECK BY A COLLAR, AND METHOD OF LIGHTENING THE JACKET BY CUTTING OUT A PORTION. (AFTER DR. GAUVAIN.)

(*e*) Some surgeons prefer to use braces rather than a plaster jacket in the treatment of Pott's disease. Many such appliances have been devised, but perhaps the most satisfactory is that known as

Taylor's brace. For a full description, larger textbooks should be consulted. It must suffice here to point out that it consists of two upright steel bars (Fig. 355), placed one on either side of the spines of the vertebræ, and carefully moulded to the back. They are connected below to a **U**-shaped piece of steel which runs down on either side to about the level of the middle of the sacrum, and is secured below by straps passing round the thighs and groins; and above they are attached to a shallower **U**-shaped steel frame which passes over the root of the neck and the clavicles. In front a leather apron (Fig. 356) covers the front of the chest and upper part of the abdomen, and is secured by straps and buckles to the brace about its centre, and to the ends of the upper **U**-shaped cross-piece. Carefully-fitted pads are placed on either side of the spine opposite the point of greatest projection and secured to the steel bars. They serve as points of pressure against the spine so as to prevent or limit deformity, whilst at the same time the upper part of the spine and the thorax are prevented from falling forwards and thus increasing the deformity. Should the cervical or cervico-dorsal region be involved, a ring or collar to support and carry the chin in a suitable position of extension, and fixed by a vertical rod to the brace, must be added to the apparatus.

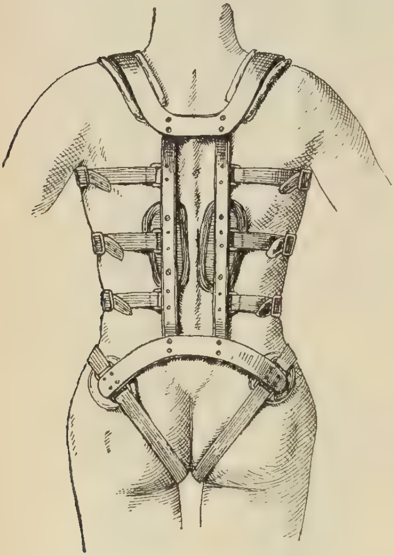

FIG. 355.—TAYLOR'S BRACE (POSTERIOR VIEW).

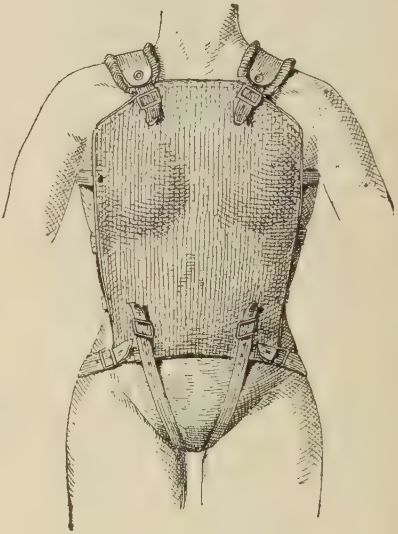

FIG. 356.—TAYLOR'S BRACE (ANTERIOR VIEW), WITH LEATHER APRON APPLIED.

During the whole course of treatment, the general condition of the individual must be carefully attended to, and suitable food and tonics administered. The child should spend as much time as possible in the open air, and preferably at the seaside. When all symptoms of pain and irritation have disappeared, the patient may be allowed gradually to get about again with a mechanical support, and, indeed, this should not be dispensed with for twelve months after apparently complete recovery.

The **Treatment of the Chronic Abscesses** is always a matter of anxiety, since, when once opened, they usually take a considerable time to heal, and if allowed to become septic the prognosis of the case is seriously affected. A general description of the methods employed has already been given at p. 186.

A *Retropharyngeal Abscess* should always be dealt with from the neck, as described in Chapter XXX.

A *Dorsal*, *Lumbar*, or *Psoas Abscess* should be tapped with a large aseptic trocar and cannula, and then irrigated, injected with sterilized iodoform emulsion, and afterwards closed without drainage. Occasionally a cure can be obtained in this way by one tapping, but only when no active disease is present, and when the patient's general health is good; more commonly the fluid will re-collect, and the same process may need to be repeated two or three times. Sometimes the fluid finds its way along the track of the cannula, and a sinus results, which must be dressed antiseptically until cicatrization has occurred. The best position in which to tap a psoas abscess is at a spot just above and internal to the anterior superior spine; a small incision is made through the skin and muscles, sufficient for the insertion of the trocar and to make certain of the absence of intestine and large bloodvessels. Should the abscess point below Poupart's ligament, close to the saphenous opening, it may be necessary to deal with it there, perhaps in addition to tapping it in the usual place. It must be remembered that the femoral vessels are displaced somewhat and stretched over the sac, and precautions should be taken to prevent puncture of the vein, an accident which has occurred.

Some prefer to open the abscess freely, and curette its interior gently with a Barker's flushing gouge. Certainly by this means the tuberculous membrane and débris, and spicules of bone, etc., can be thoroughly removed, but there is also more likelihood of a sinus remaining. Personally we are not in favour of its use for this purpose, and maintain that the method which we have advocated above is better, since there is less probability of the wound becoming infected with the tuberculous material, and hence of the formation of a sinus.

Occasionally it may seem advisable to open freely the sac of a psoas abscess, and where the disease originates in the lumbar vertebræ, it has been recommended by Sir F. Treves and others to cut down along the outer border of the erector spinæ, and deal with it from behind. A vertical incision is made in this situation, down to the transverse processes, and the lumbar fascia and quadratus lumborum are divided by a transverse cut opposite the tip of one of these; the abscess sac is then easily reached and opened. The advantage of this plan is that the bodies of the vertebræ can be examined, and even scraped, or sequestra removed.

The **Treatment of Paraplegia** arising in the course of Pott's disease consists in maintaining the immobilization of the spine by recumbency, combined with weight extension applied to both legs. At the same time, extra precautions should be adopted in order to prevent bedsores over points of pressure. Should any difficulty in micturition arise, regular catheterism must be adopted, and the greatest care directed to the sterilization of the catheters, septic cystitis being always due to external contamination. In such cases the penis and urethra must be purified, and the former wrapped in a dry aseptic dressing in the intervals between catheterism. Laminectomy (p. 698) is required in order to relieve pressure upon the cord in the following cases: (*a*) When septic cystitis or the existence of deep bedsores is threatening life; (*b*) when, in spite of complete rest, the symptoms persist or increase, and particularly when the paralytic phenomena come on rapidly, suggesting the rupture of an abscess or displacement of a fragment of bone; (*c*) when paraplegic symptoms manifest themselves late in the case, and are possibly due to a development of fibro-cicatricial tissue outside the membranes (peri-pachymeningitis). (*d*) Finally, whenever the tuberculous process mainly affects the neural arches, there is no reason for not treating it by operation, if necessary.

III. **Syphilitic Disease** of the spine develops in the shape of gummata, commencing beneath the periosteum which covers the bodies; it is of unfrequent occurrence, and gives rise to symptoms somewhat similar to those of tuberculous caries, from which the diagnosis is not always easy, apart from the history and its reaction to treatment. It usually occurs in adults, and is said to affect mainly the cervical vertebræ (Tubby); cases have been recorded in which a gumma opened into the pharynx, and portions of bone were discharged therefrom and expectorated. The co-existence of a syphilitic history and of specific lesions elsewhere may help one in coming to a decision as to the nature of the affection.

Treatment consists in the administration of suitable anti-syphilitic drugs, and in the use of a spinal support.

IV. **Rheumatic Spondylitis** is a condition occasionally met with arising from the same causes, and associated with much the same phenomena as rheumatism elsewhere. It may involve either the ligamentous or muscular tissues, or may attack the intervertebral joints. Any part of the spine is involved, but perhaps the most marked features are presented in the cervical region. Considerable impairment in the movements of the head is then produced, and the neck may be laterally deflected, somewhat simulating torticollis. If untreated, adhesions form between the bones, and the loss of movement may be permanent. Considerable pain of a neuralgic type, due to implication of or pressure upon the nerve-roots, is usually experienced. The **treatment** is of an ordinary anti-rheumatic nature, combined, perhaps, with the use of a support.

The so-called **Gonorrhœal Rheumatism** also affects the spine occasionally, and brings about much the same results.

V. **Spondylitis Deformans** is the term applied to a condition of the spine which results in rigidity and kyphosis. It is seen most frequently in old people, who become bent and shorter than formerly; but it also develops in those who have had to follow laborious occupations, especially if in the bending position, and hence is not uncommon in country workhouses and infirmaries amongst those who have had to live and work in the fields. It is more or less akin to osteo-arthritis, and characterized by very similar anatomical changes. The spine is stiff and rigid (hence the name 'poker-back' sometimes applied to it), and this results from absorption of the intervertebral discs, from synostosis of the vertebral bodies, sometimes with the formation and interlocking of osteophytes, and especially from ossification of the spinal ligaments. Pain is sometimes, but not invariably, a marked feature of the case, and is then due to irritation of nerve-roots. A large portion of the spine is usually involved, and marked kyphosis is the result. Two chief varieties have been described, but it is likely that they are merely modifications of the same process; (*a*) Von Bechterew's variety is one in which the upper cervical and dorsal regions are mainly involved, producing a limited kyphosis, with flattening of the chest and fixation of the ribs. In many of these cases evidences are present of degenerative changes in the posterior columns of the cord and of irritation of the nerve-roots. (*b*) The Strümpell-Marie type, sometimes known as *spondylose rhizomélique*, is characterized by the affection first attacking the lower portion of the spine, but it also involves the hip and shoulder joints. In both forms there is a gradual extension of the process through the whole length of the column, and finally it attacks the articulations between the ribs and the vertebræ; when these become fixed, the respiratory movements are considerably impaired, and hence death is likely to ensue from pulmonary mischief. Treatment must follow along the lines laid down for osteo-arthritis.

Tumours of the Spine are usually malignant in character, and most commonly secondary to cancer or sarcoma elsewhere. Simple tumours, such as chondroma, osteoma and hydatid cysts, do occur, as also primary sarcoma. The chief symptoms are severe and localized pain, which is constant, and unrelieved by rest in the recumbent posture, together with early excurvation and paraplegia. Deformity is, however, by no means constant. Neuralgic pain and motor spasms, due to involvement of the nerve-roots, may considerably aggravate the patient's sufferings. These phenomena manifesting themselves in an adult should always suggest the presence of a morbid growth, and the more rapid the onset, the more likely is a diagnosis of malignant disease. Treatment necessarily is but rarely feasible, although an exploratory operation is quite justifiable if the disease is primary and the patient not profoundly cachectic.

Tumours of the Spinal Cord and Membranes develop in several situations, and the symptoms are thereby somewhat modified. (*a*) *Outside the spinal* *dura.* Lipoma and sarcoma are here most often seen, and the symptoms of cord pressure, such as loss of power and sensation, are preceded by those of spinal irritation, *e.g.*, neuralgic pain, increased on movement, and are often limited for some time to one side. Multiple neuro-fibromata of the nerve-roots are by no means uncommon. (*b*) They may grow *from the inner aspect of the dura mater*, and thus produce symptoms of cord pressure and meningeal irritation concurrently. Sarcoma, endothelioma, fibroma and gumma, are the commonest forms of neoplasm in this situation. (*c*) *From the spinal cord* itself, myxoma, psammoma, and sarcoma may originate. The symptoms are those of paraplegia combined with some localized and referred pain or tenderness, and either bilateral from the start, or sometimes of the crossed type, anæsthesia being marked on one side of the body, and paralysis and hyperæsthesia on the other—*i.e.*, on the side of the tumour. Left to themselves, patients suffering from any of these growths are certain to die, and hence an exploratory laminectomy, with a view to removal of the growth, if practicable, is always indicated when a diagnosis has been effected. The possibility of the disease being syphilitic in origin must not be overlooked, and hence a preliminary thorough course of iodide of potassium and mercury should always be instituted before operating. The results hitherto obtained have been distinctly encouraging, although many of the cases are left till too late, and the mortality is certain to be high.

The only inflammatory disease of the cord which need be alluded to here is one the results of which have already been mentioned constantly in the chapter dealing with the deformities of the body (Chapter XIX.), viz., **Infantile Paralysis.**

This condition is undoubtedly infective in nature, although there is still some doubt as to the actual causative organisms; the meningococcus and staphylococcus have been isolated from the cerebro-spinal fluid. It mainly affects children in the first three years of life; it is especially common in the Tropics, and shows a seasonal variation in this country, three-quarters of the cases occurring between June and October; it is occasionally epidemic, and may attack several members of a family. The part attacked is chiefly the anterior cornua of the grey substance of the cord (*acute anterior poliomyelitis*), as a result of which the multipolar ganglion cells situated therein are destroyed, and this is followed by secondary degeneration of peripheral nerves and muscles. The **symptoms** come on abruptly, and are often introduced by a short febrile attack with pain in the back and head; paralysis usually shows itself within three to ten days; occasionally the general symptoms are scarcely noticeable, and the onset of the paralysis is merely associated with some irritability. In all cases the paralysis quickly reaches its maximum, perhaps, indeed, in a few hours; it generally remains stationary for a period of from one to four weeks, and then a certain amount of recovery ensues, possibly rapid at first, but slower subsequently. The portions that remain paralyzed early lose their nutrition, owing to the destruction of their trophic ganglionic centres, and become cold and bluish in colour; they do not respond to the faradic current, and even the reaction of degeneration is lost; finally, deformities due to the unbalanced action of opposing groups of healthy muscles may appear, whilst the development and growth of the affected limbs are impaired. The distribution of this affection is very variable, but, speaking generally, the legs are most commonly affected, the lower halves, and not the upper, being mainly involved; various forms of talipes may result therefrom, as also weak and flail-like conditions of the knee and ankle. When the thigh is included, the quadriceps extensor and adductors are usually picked out. In the arm the deltoid is most often paralyzed, and after this the muscles on the extensor side of the forearm, including the supinator longus. The face and neck are rarely involved, but the abdominal and back muscles may be attacked. The **Treatment** in the early stages is directed towards improving the general health, and disinfecting the alimentary canal, from which the infection probably arises. The nutrition of the affected muscles is maintained as far as possible by electricity and massage, and deformities are prevented by suitable splints directed to keeping the affected muscles relaxed and not stretched. In the later stages, when deformed, or weak and flail-like, limbs have resulted, various means may be adopted in order to improve the functions of the part. (*a*) *Mechanical support* is often needed, and this must be carefully regulated, in order to assist, and not to hamper, the movements of the individual by its unnecessary weight. In paralytic talipes, irons fixed to the boots, and rising above the knee, or even sometimes running up to the pelvis, are frequently required. (*b*) ***Tenotomy***, or division of muscles or fasciæ, may also be needed in certain deformities. (*c*) ***Tenoplasty***, or the grafting of a healthy tendon into a paralyzed one, has been occasionally utilized, as also the transplantation of the bony attachments so as to put the relaxed and weak muscles on the stretch (p. 426). (*d*) *Arthrodesis*, or the fixation of joints, is a useful proceeding under circumstances where the unnatural mobility is difficult to control, or would necessitate considerable increase in the weight of the apparatus required, or where, from the poverty of the patient, the apparatus cannot be obtained. It is especially serviceable in cases where two joints in a limb are flail-like, one of which may then be ankylosed with advantage. The operation consists in a modified excision, the cartilage alone being sawn or scraped from the ends of the bones, but it must always be remembered that the reparative activity in paralyzed limbs is small. (*e*) Where the whole limb is hopelessly powerless and a great inconvenience to the patient, *amputation* is often the best practice. In the lower extremity, when the knee and ankle are both weak and flail-like, arthrodesis of the knee and removal of the foot by a Syme's amputation will often provide the patient with a serviceable limb.

CHAPTER XXVI.

AFFECTIONS OF THE SCALP AND CRANIUM.

Affections of the Scalp.

Wounds of the scalp are produced either by sharp or blunt instruments, by falls on the head, or by gunshot injuries. From the tenseness of the scalp over the cranium, it sometimes happens that a blunt weapon, such as a policeman's truncheon, will cause a wound nearly as cleanly cut as if it had been made with a sharp instrument. So long as the wound is superficial to the occipito-frontalis aponeurosis, but little harm is done; if, however, the layer of loose cellular tissue between the aponeurosis and the pericranium (the ' dangerous area ') is opened up and infected, cellulitis (p. 88) is likely to ensue. The vascular supply of the scalp is so good that sloughing is uncommon; a large portion may be torn and bruised, and yet, if it is carefully washed and rendered aseptic, there is every probability that it will retain its vitality. *Complete avulsion* of the scalp usually occurs in women from their hair being caught in machinery. The skin yields just above the ears and supra-orbital ridges, and the aponeurosis is cleanly torn off. Replacement is of course hopeless when separation is complete, and Thiersch-grafting must be relied on for obtaining an epithelial covering to the raw surface.

Treatment.—The hair should be cut away from the neighbourhood of the wound, which is purified with Lister's strong mixture; the edges may be excised if badly bruised or very dirty. The iodine method of gaining asepsis (p. 279) is particularly useful in injuries of this nature, and may limit the extent of skin requiring to be shaved. Stitches are introduced to draw the parts together, and for choice are of a non-absorbent variety, *e.g.*, horsehair. Hæmorrhage from the scalp is often severe, owing to the density of the tissues, which prevents contraction and retraction of the divided vessels. For a similar reason it is sometimes difficult to secure them by ligature, and a suture must then be passed under the vessel in such a way as to control it.

Hæmatoma of the scalp results from injuries that are not associated with solution of continuity of the surface. A similar condition is found in infants; it is due either to pressure or injury to the head during its passage through the mother's pelvis, or to the compression of obstetric instruments. Three varieties of cephalhæmatoma have been described, viz.: (*a*) the *Superficial*, which, confined to the dense subcutaneous tissue, is necessarily small. (*b*) The *Subaponeurotic* occupies the loose tissue under the aponeurosis, and is only limited by the attachments of this structure. It forms a large, soft, fluctuating swelling, upon which the scalp appears to float, bagging down over the eyes or occiput. It is often due to fracture of the underlying bone. (*c*) The *Subpericranial* is limited by the pericranium dipping down into the sutures around the bone with which it is connected. Most commonly it forms over one of the parietal bones in infants, presenting a soft, fluctuating swelling, which soon gains an indurated margin owing to a deposit of fibrin, and in this condition may simulate a depressed fracture of the skull, inasmuch as the cup-like fluid centre allows the finger to sink in and touch bone below. The indurated margin, however, can be readily indented by the finger, whilst the edge is definitely raised above the surface of the cranium, and hence the sensation of depression of bone felt through the fluid is only apparent. In old-standing cases ossification of the walls of this cavity has even been known to occur. **Treatment**.—All that is required is the application of evaporating lotions. There is hardly ever any need to lay open or drain these swellings unless underlying mischief is present.

Suppuration of the scalp is of common occurrence, arising mainly from external infection, but being occasionally due to disease of the subjacent bones. The extent of the abscesses is limited by the same anatomical features as obtain in connection with hæmorrhage. Thus, a *subcutaneous* abscess is necessarily small in size, owing to the density of the tissues in which it is located; it arises most frequently as a result of eczema or impetigo, and is often due to the presence of pediculi, or to the action of irritants used in the cure of ringworm. A *subaponeurotic* abscess usually results from a penetrating wound, and is associated with cellulitis. A *subpericranial* abscess is rarely seen except in connection with injury or disease of the bony calvarium; the pus is limited to the affected portion of bone.

For **Erysipelas** and **Cellulitis** of the scalp, see pp. 131 and 88.

Tumours of the scalp are of many types.

Ordinary *traumatic aneurisms* or *arterio venous* wounds of the temporal trunk are uncommon; they rarely attain any considerable size, and are readily treated by excision. A curious dilated and tortuous condition of one of the scalp arteries, most often the temporal, is occasionally seen, and is known as an *arterial varix*; it may be treated by complete excision.

Nævi of the scalp do not differ in their characters from those seen elsewhere, except that when situated over the anterior fontanelle they may derive a communicated impulse from the subjacent dura, and so be mistaken for a meningocele.

Cirsoid Aneurism is more frequently met with in the scalp than elsewhere, and mainly involves the auriculo-temporal region, but may also spread in all directions, even downwards into the neck. The origin is very uncertain; in a few cases it has been preceded by a nævus, and sometimes there is a history of injury. A tumour of greater or less size is seen under the skin, consisting of distended, tortuous, pulsating, bluish-looking vessels, the arteries opening directly into cavernous spaces without the intervention of capillaries; it is easily emptied by pressure, but quickly refills, owing to the abundant arterial supply. The rate of growth is variable, and the patient often complains of headache and giddiness; the skin becomes thin and atrophic, the hair falls out, and finally ulceration may occur, the patient probably dying from hæmorrhage. The **Treatment** is eminently unsatisfactory, complete excision being the ideal cure, but this in the worst cases is impracticable. If it be attempted, the incisions should be made wide of the disease, and the supplying vessels secured, if possible, between double ligatures before dividing them; if this precaution is not adopted, frightful hæmorrhage may result. It is necessary in some cases to deal with the tumour in separate segments, allowing time between the operations for the patient to recover from the loss of blood. Probably *electrolysis*, combined with ligature of the main nutrient vessels, holds out the best chance of success. (For methods of electrolysis, see p. 53.)

Papillomata are not uncommon in the form of small hard warty outgrowths, giving rise to but little inconvenience, unless situated on some spot where the hat rests. They are easily removed.

Lipomata also occur, and are usually situated in front, arising from the deeper layers of the scalp or from the pericranium. They generally expand laterally and are flattened. Removal is readily effected.

Epithelioma also occurs, arising either from an irritated papilloma, or possibly in connection with a sebaceous cyst. As soon as a diagnosis is made, the growth should, if possible, be extirpated, and the resulting raw surface may be either left to granulate, or dealt with by Thiersch's method of skin-grafting.

Fibroma may occur in the shape of a localized development of hard fibrous tissue, and often grows on the forehead where the hat crosses it; or it may attain much larger dimensions, involving perhaps half the scalp, and giving rise to an irregular nodulated outgrowth of soft fibro-cellular tissue, which has sometimes been termed a *pachydermatocele* (p. 214), and is then of neuro-fibromatous origin. Either form may be dealt with by excision.

Sarcomata of the scalp are uncommon apart from a similar affection of the underlying bones. They present as large fleshy tumours which may pulsate or fungate, and usually develop rapidly, but are limited for some time by the aponeurosis of the occipito-frontalis. Treatment by a wide excision and Thiersch-grafting may be possible, but if the condition is at all advanced this is hopeless, and reliance must be placed on radium or X rays.

Dermoid Cysts are by no means uncommon in this region, their favourite situation being near the outer canthus, the temple, or the root of the nose. For a general description, see p. 229. They do not attain any great size, and may not become evident till after puberty. The underlying bone is often hollowed out from a defective development of the mesoblastic tissues around them; and a congenital opening may even exist through which a narrow neck passes, bringing the cyst into direct connection with the dura mater. The *treatment* consists in removal; but it is advisable to delay this till after puberty if the tumour seems at all fixed to the skull, or if the bone is felt to be defective beneath it, as in such cases the communication with the interior of the cranium is often shut off by that time.

Sebaceous Cysts (p. 409) find their most usual situation in the scalp, where they not only are frequently multiple, but also may reach a considerable size. Their removal is best accomplished by transfixion, squeezing out the contents, and picking out the cyst wall by a pair of forceps without dissection. The wound is closed by one or two stitches.

Sebaceous Adenoma is most frequently seen on the scalp (p. 410).

Affections of the Cranium.

I. Congenital Affections.

1. In babies the ossification of the bones may be incomplete, constituting what is known as *aplasia cranii congenita*, and is due to a cachectic condition of the mother. Occasionally a similar atrophic condition of the bones may persist through life, exposing the patient to increased risk from injuries which otherwise would do but little harm.

2. **Meningocele, Encephalocele,** and **Hydrencephalocele** consist of a protrusion of the dura mater, with or without part of the brain, through an opening in the cranial wall. They are due to defective intrusion of the mesoblastic tissues outside the primitive cerebral vesicle, so that part of the brain or its membranes remains superficial and extracranial. They occur most frequently at the root of the nose, and in the occipital region (Fig. 357), occasionally at the anterior or lateral fontanelle, or at the base of the skull. A *Menin*

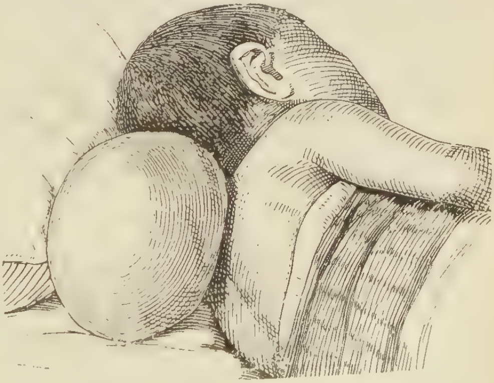

FIG. 357.—CONGENITAL ENCEPHALOCELE OF THE OCCIPITAL REGION. (TILLMANNS.)

gocele is simply a protrusion of the brain membranes containing cerebro-spinal fluid. It forms a soft, rounded, fluctuating swelling, attached to the skull by a base of greater or less size, and covered by skin, which may be thick and healthy, or thinned, bluish, and translucent when the tumour is large. The vessels present in the skin are often dilated and nævoid. It increases in size and tension on any expiratory effort, such as coughing or crying, and it may be partially reducible, thus allowing the margins of the opening in the cranium to be defined. Symptoms of cerebral compression, convulsions, etc., are likely to be produced by such manipulation. An *Encephalocele* is a similar type of tumour, but contains brain substance, and pulsates almost synchronously with the heart; it is most commonly situated at the back of the skull. A *Hydrencephalocele*, or Meningo-encephalocele, is a condition in which the tumour contains both brain substance and fluid. Two varieties have been described—one in which there is a small protrusion of the brain associated with an ordinary meningocele, and the other in which the fluid is contained in a cavity communicating with one of the ventricles, and covered by a thin layer of brain substance. They are usually of considerable size, constituting a type of hydrocephalus, and are situated in the occipital region, either above the tentorium, and then possibly associated with distension of the posterior cornu of one of the lateral ventricles, or below that structure, the osseous defect extending in some cases as far as the foramen magnum, and a portion of the cerebellum being within the sac.

The **Prognosis** of these conditions is exceedingly grave. Fortunately, many of the subjects are born dead, or die soon after birth. In the more severe cases, idiocy and microcephaly are not uncommonly associated, whilst sometimes true internal hydrocephalus is present. The protrusion may increase steadily in size and finally burst, causing death by purulent meningitis, or in more favourable cases it may remain stationary. In a meningocele, the subsequent growth of the cranial bones may suffice to close the communication between the interior and the tumour, which thus becomes shut off, and remains as a cyst-like swelling, with the base fixed, and without pulsation or respiratory impulse.

Treatment.—Most cases should be left alone; but if the tumour is steadily increasing in size, aseptic puncture and subsequent compression may hinder the process; a pure meningocele may possibly be cured in this way. Where the communication with the skull is small, it may be feasible to excise the tumour, taking special care to suture the base securely, and attempting when practicable to make good the cranial deficiency by osteoplasty.

II. **Acquired Affections** of the skull are atrophic, hypertrophic, inflammatory, or neoplastic in nature.

Acquired Atrophy of the skull occurs in many forms:

(*a*) *Craniotabes* is a condition met with during the first year of life, usually as a result of inherited syphilis (p. 581).

(*b*) *Senile* atrophy may affect the whole cranium, which becomes thinned and rarefied; or it may be localized, as pointed out by the late Sir G. M. Humphry,* to the parietal bones, constituting hollow depressions which extend antero-posteriorly. No symptoms are caused thereby.

(*c*) Localized loss of substance may result from the pressure of tumours, such as Pacchionian bodies and aneurisms, or from necrosis, or traumatic and operative lesions. If these are at all extensive, the cerebral pulsations can be felt distinctly through the skin. It is then advisable to provide the patient with some guard to protect him from injury. This may be accomplished by means of a metal plate worn over the scalp; but of late years operative measures have been introduced to obviate this. *Autoplasty* is the term applied to a proceeding whereby the defect is closed by a plate of bone removed from the patient's own skull. A suitable scalp flap is turned down, and then a portion of the outer table is chiselled up sufficient in size to close the aperture. The pericranium is utilized on one side as a pedicle, and by means of this it is stitched down into the gap, the margins of which have been previously freshened. By *heteroplasty* is meant a similar proceeding when the hole is closed by a plate of gold, platinum, or vulcanite, fixed by wires or nails to the surrounding bone. The results of these procedures have been on the whole satisfactory.

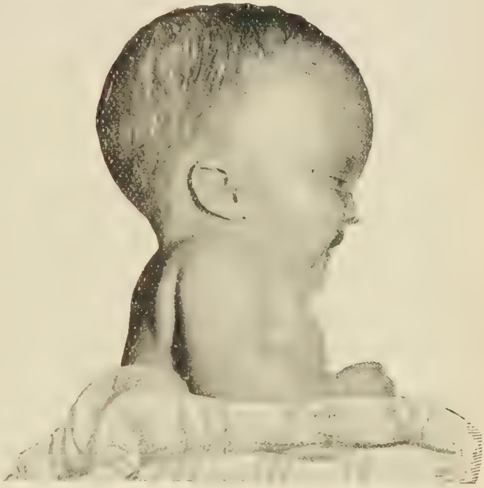

FIG. 358.—HYDROCEPHALUS.

(From photograph, by permission of Mr. F. F Burghard.)

(*d*) *Chronic Internal Hydrocephalus* is always associated with atrophy and thinning of the cranium; it may be congenital, or may commence early in life. It is produced in almost all cases by a distension of the lateral ventricles with fluid, the result of congenital malformation or of inflammatory affections, causing exudation from the choroid plexuses, pressure upon the veins of Galen or inferior longitudinal sinus, and possibly closure of the foramina of Magendie and Luschka. The head becomes more and more distended (Fig. 358), the bones expanded and thinned, and the sutural areas increased, whilst the brain is subjected to such pressure as may be incompatible with life. Fluctuation is distinctly felt, and the bones may crackle under the fingers; the face looks abnormally small, and the eyes protrude, owing to the depression of the orbital plates. *Treatment.*—Tapping of the ventricles is useless, as even if a considerable amount of the fluid is withdrawn, and elastic pressure subsequently maintained, recurrence is almost inevitable. The only hope is to establish a free communication between the ventricular and subdural spaces, so that the excess of fluid in the ventricles may escape; it will be absorbed from the subdural space as soon as the tension rises above the intravenous pressure. A silver tube should be inserted between the two spaces, or a tube of decalcified bone carrying a catgut drain; to be of any value, the operation must be undertaken before the cerebral cortex has been so thinned as to interfere with its functional activity.

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* *Med.-Chir. Trans.*, 1890, p. 37

(*e*) By *Microcephaly* is meant a condition of diminished size of the cranial cavity due to premature ossification of the sutures, and resulting from non-development of the brain. It is usually associated with idiocy, and possibly with cretinism. Attempts have been made to relieve this by the operation of linear craniectomy or removal of portions of the cranium, so as to allow of the expansion of the brain. Temporary improvement has followed in a few cases, probably from the individual attention given to the patient; the final result is extremely uncertain, most of the patients relapsing owing to the contraction of the dense cicatricial material which replaces the bone, and to the atrophic condition of the brain.

Hypertrophic Changes of the Skull result from simple chronic inflammatory affections, or from injury, etc. Special types of enlargement are seen in inherited syphilis (p. 580), rickets (p. 582), osteitis deformans (p. 587), and acromegaly (p. 589). In leontiasis ossea (p. 803) the cranium becomes thickened and enlarged; but the cranial cavity is also encroached on, constituting what is known as *concentric* hypertrophy, in contrast to most of the other forms, which are *eccentric* in type.

Inflammatory Affections of the Cranial Bones.—The cranium is liable to any of the diseases which generally occur in bone.

1. **Acute Periostitis, or Pericranitis,** is usually infective in origin, following cellulitis of the scalp; it is likely to result in necrosis of the outer table.

2. **Acute Infective Osteo-myelitis,** or acute necrosis, consists of an acute inflammation of the diploe, due to pyogenic organisms, and either following an infected scalp wound or compound fracture, infective inflammation of one of the air-sinuses or the operation necessary for its treatment, or a simple contusion of the bone in a person of low germicidal powers. The symptoms and signs are those generally characteristic of the disease, being ushered in by a rigor, followed by headache, fever, and the development of a localized œdematous swelling, known as ‘ Pott's puffy tumour ’ (Fig. 367). The pericranium is stripped up by diffuse suppuration beneath it, and an abscess often forms between the bone and the dura mater. Necrosis of the whole thickness of the skull is likely to follow, but is usually limited

by the sutures to the particular bone affected. Pyæmia and extension of the inflammation to the membranes, venous sinuses or brain, are the chief dangers arising from it. The prognosis is always grave, even when early operative treatment is undertaken; apart from operation, it is almost hopeless. The *Treatment* consists in free external drainage, together with the removal of the outer table to enable the infected diploe to be curetted. If signs of subcranial suppuration ensue (p. 765), the inner table must also be removed. It is not always necessary to wait for the spontaneous separation of the sequestrum; dead bone may be chiselled away at an earlier stage.

3. **Chronic Periostitis** of the cranium is occasionally met with in the form of a node. It is usually the result of some long-continued irritation, such as carrying baskets or weights on the head. *Treatment* consists in the removal of the irritation, and there is no objection to chiselling away the node, if necessary.

4. **Tuberculous Disease** of the cranial bones is not common; it occurs as a primary phenomenon, or is secondary either to a cutaneous lesion, such as lupus, or perhaps more commonly to a meningeal focus. It may start in the periosteum or diploe, leading to the formation of a node, or perhaps to expansion of the bone, and followed by suppuration and caries. When of meningeal origin, there is a considerable amount of erosion of the inner table, and possibly some necrosis; sooner or later the outer table is perforated and a subpericranial abscess forms. The amount of mischief in the outer table is no criterion of the extent of the disease within, and hence very thorough exploration is necessary. The prognosis in this variety is not good. The mastoid process and the orbital margin in the neighbourhood of the external angular process of the frontal bone are rather favourite situations for the disease, which is then often accompanied by other manifestations.

5. **Syphilitic Disease** of the cranium, on the other hand, is exceedingly common, occurring usually in the tertiary stage, and affecting most frequently the frontal and parietal bones. It has been already described (p. 579).

Tumours of the Cranial Bones.—The chief **Tumours** affecting the calvarium are osteomata and sarcomata.

Osteoma of the cranium (Fig. 57) occurs as a localized overgrowth of compact bone from the outer surface of the calvarium, from the inner, or from both. The frontal bone and external auditory meatus are the sites of election. If arising externally, a smooth, rounded, globular swelling is produced, hard to the touch, quite painless, and fixed to the subjacent bone by a broad base; more than one may be present. If the main growth is internal, symptoms of cerebral irritation or pressure may be produced. Osteomata are to be distinguished from inflammatory hyperostoses (usually of syphilitic origin) by their sharp limitation, absence of pain, and slower progress: whilst osteo-sarcomata are commonly rapid in growth, painful, and of unequal consistency in different parts. **Treatment** is rarely necessary. Small growths may be encircled in the crown of a trephine and thus removed. Large ones must be dealt with by a burr driven by an electric engine, the bone being divided just outside the dense compact tissue, and thus the tumour is set free. No attempt should be made to chisel away these growths, as symptoms of concussion may follow the prolonged use of the chisel and mallet against the skull.

Sarcoma of the cranium originates either from the pericranium, the diploe, or from the dura mater.

The *pericranial* variety consists of a round or spindle-celled tumour growing from the pericranium, and possibly attaining a considerable size. It may contain a certain amount of ossific deposit, or the tumour remains of a soft consistency, and then often pulsates. The subjacent bone is sometimes absorbed, and the dura mater affected secondarily. General infection of the system follows.

Central Sarcoma commences in the diploe and spreads both outwardly and inwards. In this situation, however, a *myeloma* may develop, and simulates a sarcoma; its growth, however, is slower, and it is covered with a thin layer of bone, which may crackle beneath the fingers.

Sarcoma of the dura mater may be attributed to some injury to the head, and is characterized by the occurrence of severe cerebral symptoms—*e.g.*, intolerable localized headache, epileptic fits, double vision, optic neuritis, etc.—prior to any evident appearance of a tumour. Gradually the bones become expanded and perforated, and a soft and exceedingly vascular pulsating growth is felt beneath the scalp. This fungates sooner or later, and possibly the meningeal cavity is laid open by ulceration, death from septic meningitis, cerebral compression, or exhaustion, ending the chapter.

Treatment.—These cases have usually gone too far for operative treatment before being recognised. As a rule, radio-therapy can alone be relied on, or that conjoined with a course of Coley's fluid.

Secondary Carcinoma of the cranial bones is by no means uncommon, and may follow cancers of the mamma, thyroid body, etc. The growths are usually small and multiple, and may show pulsation. Neuralgia and persistent headache may result from them.

III. Traumatic Affections of the Cranium.

Contusions of the Cranial Bones apart from fracture may lead to serious results. 1. Many of the inflammatory conditions of bone just described may be originated; *e.g.*, if the patient is in a condition of low germicidal power, acute osteo-myelitis may follow; or chronic sclerosis and overgrowth of the bone, local or diffuse, may supervene. Syphilitic or tuberculous manifestations may be similarly lighted up if the patient is the subject of either of these diseases. 2. In addition to such osseous conditions, pus may form within the cranium outside the dura mater (*subcranial abscess*, p. 764), and necessitate trephining 3. The dura mater may be detached by a simple contusion, leading to meningeal hæmorrhage (p. 761). 4. Any of the cerebral lesions detailed hereafter may be produced. Contusions of the cranium must obviously never be treated lightly, even when they are associated with unbroken skin; much more are they serious when compound, owing to the risks of infection.

Fractures of the Skull may be described for convenience under the following headings: *Fissured Fractures of the Vault; Fractures of the Base* (usually fissured); and *Depressed or Punctured Fractures.*

1. **Fissured Fractures of the Vault** are always due to external violence, direct or indirect. In the former case the skull first yields at the injured spot, but the fissure may extend from it for some distance; in the latter the fracture results from the yielding of the skull when compressed beyond its natural limits of elasticity.

A simple fissure gives rise to no symptoms indicating its presence with certainty. There may be some amount of superficial ecchymosis, but nothing more definite. When compound, the line of fracture may be seen as a red streak, or even felt with the finger as an irregular ridge. It consists of a mere longitudinal fissure, or may be starred; if uncomplicated, it is of but little importance, and needs nothing beyond general treatment—of course, the greatest care being taken to ensure asepsis. Occasionally, however, an osseous growth forms from protuberant callus on the inner aspect of the cranium at the site of fracture, and gives rise to traumatic epilepsy or insanity (p. 780).

Traumatic Cephal-hydrocele is the name given to a rare condition following simple fractures of the vault, especially in children. It is characterized by the formation of a fluid swelling under the scalp, which pulsates synchronously with the heart-beat, and has a definite impulse on any expiratory effort; it varies in size from time to time, and is sometimes partially reducible. It contains cerebro-spinal fluid, and communicates with either one of the lateral ventricles or the subarachnoid cavity. In one case it was proved on operation to be connected with an arachnoid cyst, due to a localized subarachnoid hæmorrhage. Probably it is wise to leave this condition alone, although, if one could be tolerably certain that the ventricle was not affected, it might be laid open and drained.

2. **Fractures of the Base of the Skull** are almost always fissured, only occasionally punctured or depressed.

Causes.—(*a*) *Violence may be directed to the vertex or to some part of the cranial convexity*, as from a blow or fall upon a hard substance. There has been a good deal of discussion as to how a fall on the vertex causes fracture of the base. Two main theories hold the field, each being probably responsible for a certain number of cases. (i.) Aran's theory of *irradiation* maintains that a fracture of the base is always due to direct extension of the fissure from the injured vertex, a proposition probably quite true in many cases, but insufficient to explain all. (ii.) A more recent idea, known as the *bursting or compression theory*, is based on the fact that the cranium is not a solid and totally unimpressionable body, but is highly elastic, as has been proved by the observation that hair and even pieces of skin have been found nipped in a fissured fracture of the vault, which had evidently gaped open and closed again. Severe compression necessarily diminishes the diameter of the skull along the axis of greatest pressure, making it bulge in other diameters; if this exceeds the limits of elasticity of the bone, a fracture must result. The direction of fractures produced in this manner varies. Most commonly the lines of fracture are parallel to the direction of the compressing force, the bone thus bursting open along its convexity (fracture by bursting); less frequently it gives way at right angles to the direction of the force (fracture by compression). Inasmuch as the force is transmitted equally in all directions, the weakest and least elastic part is always most likely to give way, viz., the base. Whether these ideas are justified is a question; certainly the figures quoted by Phelps* indicate that irradiation is responsible for a very large proportion of fractures of the base. (*b*) *Direct or indirect injury* to the base of the skull is undoubtedly the cause of a certain number of fractures, and some of these are depressed, and not fissured, in character. Thus, the point of an umbrella or stick may be thrust through the upper wall of the orbit, or up the nose through the cribriform plate of the ethmoid; the condyle of the jaw may be driven through the glenoid cavity into the middle fossa by a blow on the chin; direct injury from a fall or a stab may penetrate the occipital bone; whilst a gunshot wound in the mouth is another illustration of this kind of injury. (*c*) The *impact or resistance of the vertebral column against the occipital condyles* produces fractures in the posterior fossa which radiate from the foramen magnum, and may even occasion a ring-shaped fracture around it (Fig. 359). They result from falling on the vertex into a soft mass—*e.g.*, a bale of wool—or by alighting from a height on the heels or nates.

The fracture may run in any *direction*, longitudinal, oblique, transverse, etc., according to the direction of the compressing or fracturing force, and it may affect any part of the base, either being limited to one of the fossæ or involving all; it may follow the sutural lines in part, but it is no uncommon thing to see even the dense petrous bone traversed by a fissure (Fig. 360). Naturally, transverse fractures are more likely to be limited to one of the fossæ, whilst a longitudinal fissure may involve them all.

Some fractures of the base of the skull are simple in nature, but the majority are *compound*. In the anterior fossa the fissure extends through the cribriform plate and nasal mucosa, and then lays open the nose; or a communication may be established with the external air through a penetrating wound in the orbit, or through the ethmoidal or sphenoidal sinuses. In the middle fossa a fracture through the base of the sphenoid opens the roof of the naso-pharynx, or the fracture may involve the tympanic cavity. In the posterior fossa the basi-occipital may be broken, and again the naso-pharynx opened, although the fracture here is more commonly simple.

* 'Traumatic Lacerations of the Brain.' London: Henry Kimpton; 1898.

Fractures of the base of the skull, though very serious, are by no means necessarily fatal, and since the introduction of antiseptic work the results have immensely improved. The main *dangers* to be apprehended are: (i.) Damage to the base of the brain, including the pons and medulla, especially in cases where the foramen magnum is splintered from the impact of the spine against the condyles; (ii.) hæmorrhage arising either from the venous sinuses, or from the meningeal or cerebral arteries; and (iii.) infective meningitis, due to the fact that the injury not only fractures the bones, but also lays open the dura mater, a grave addition to a compound fracture.

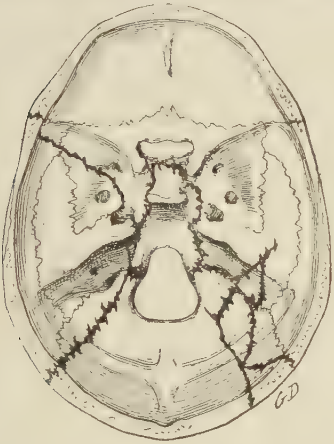

Fig. 359.—Fracture of the Base of the Skull from Force acting against the Occipital Condyles, and producing almost an Annular Fracture around the Foramen Magnum.

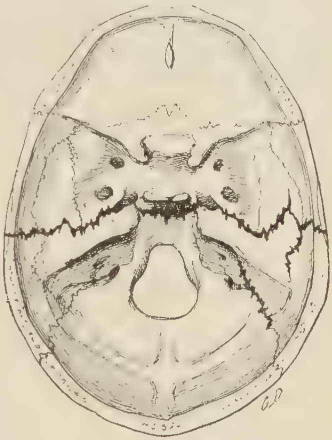

Fig. 360.—Transverse Fracture across the Base of the Skull.

The **Signs** of a fractured base are sometimes exceedingly equivocal, but for convenience may be arranged under four heads:

(1) *Signs of severe cerebral mischief*, such as concussion of the brain and prolonged unconsciousness. This is, however, by no means always present; thus, in a case we had in hospital some years back, the patient was capable of going about his work for ten days after the accident.

(2) *Hæmorrhage* manifests itself in various directions, according to the situation of the fracture.

In the *anterior fossa* there may be free bleeding from the nose, owing to the fracture extending through the cribriform plate of the ethmoid; but a portion of the blood may pass backwards into the pharynx, and, being swallowed, is perhaps subsequently vomited. More often, however, the line of fracture runs across the roof of the orbit, causing escape of blood into the areolar tissue of this cavity. The ecchymosis shows itself as a gradually developing subcutaneous distension, involving the lower lid, bluish-purple in colour at first, but passing later through the other stages of a bruise; there is probably no contusion of the skin, as in the ordinary black eye, which is at first reddish-purple; the ocular conjunctiva is considerably involved, but the effusion rarely extends above the cornea, and its posterior limits cannot be seen. The bleeding usually arises from laceration of the dura mater and bone, but, when abundant, may come from the cavernous sinus, and the eye may even be pushed forwards (proptosis); in some cases pulsation is to be felt within the orbit, and then a traumatic orbital aneurism or aneurismal varix is present.

In the *middle fossa* the blood may enter the nose or mouth, a part being swallowed, but more commonly it escapes from the ears. If abundant, it probably comes from one of the vascular channels at the base of the brain; but if only slight in amount and of short duration, it may be induced by any of the following lesions, as well as by a fractured base, viz.: (*a*) A simple rupture of the membrana tympani; (*b*) separation of the cartilage of the pinna, with tearing of the lining of the external meatus; (*c*) fracture of the anterior and lower part of the tympanic plate, as by a blow on the jaw, which drives the condyle forcibly against it.

In the *posterior fossa* the bleeding is usually subcutaneous, showing itself around the mastoid process, and extending downwards amongst the muscles at the back of the neck.

(3) *Discharge of cerebro-spinal fluid* is an indication that a communication exists with the subdural space. The fluid may be discharged from one or both ears, but has also been met with coming from the nose or cranial vault; when from the ear, the dura mater has probably been laid open through the prolongation which accompanies the auditory nerve in the internal meatus by a fracture traversing the petrous bone. It is watery and limpid in character, with a specific gravity of about 1006 to 1008, slightly alkaline, and containing a fair quantity of chloride of sodium, with traces of albumen, and of a substance which, like grape-sugar, reduces cupric salts on boiling. At first it is probably blood-stained, but soon becomes quite clear. The amount discharged may be small, but not unfrequently it comes away in large quantities, soaking the pillow and dressings, and, indeed, can sometimes be caught in a test-tube as it trickles from the meatus. As a rule, the flow commences soon after the injury, and quickly ceases; but some years back a curious case occurred, under the care of Lord Lister at King's College Hospital, of a man who had fallen backwards off a high bed upon his occiput; he was temporarily stunned, but returned to bed, and, on awaking the next morning, found that both eyes were black. He continued work for ten days, complaining, however, of headache, and at the end of that time of earache, which grew steadily worse, until relieved by something giving way in his left ear. This was followed by a copious discharge of cerebro-spinal fluid, which was maintained for some time, and from the after-history there can be no doubt that it was due to a fractured base.

Escape of brain substance from the ear has also occurred in a few instances, most of them fatal.

(4) *Lesions of the nerves* issuing from the base of the skull are occasionally produced. For symptoms, etc., see Chapter XVI. The nerve most commonly involved is the facial, as it passes through the aqueductus Fallopii; the paralysis may develop either immediately, or more often about the second or third week after the injury, disappearing in about a month, and then evidently due to its implication in the callus. A certain amount of deafness is often associated with it from injury to the auditory nerve.

The **Prognosis** of a fractured base has much improved during recent years, as a result of the application of antiseptics to the auditory meatus. If the patient escapes death from cerebral complications, the bones of the skull unite rapidly, and a good result may be expected, although troublesome sequelæ may follow, from the injury sustained by nerves or vessels, or of their compression in callus or new bone.

Treatment.—Seeing that the chief danger to the patient arises from septic contamination of the meninges, the greatest care must be directed towards preventing decomposition of the discharges. Unfortunately, it is impossible to apply dressings to the naso-pharynx, or even to wash it out thoroughly with antiseptics, and the only satisfaction about such cases is that the rarity of the loss of cerebrospinal fluid suggests that the membranes of the brain are not very often damaged in that situation, whilst it has also been shown that in the majority of cases the upper part of the nasal cavity is aseptic (St. Clair Thomson). With the ear, however, things are very different; the meatus should be well, but gently, irrigated with carbolic lotion (1 in 20), and a strip of sterile gauze passed down it, a large pad of the same being bandaged over the affected side of the head. This must be replaced as often as necessary. Beyond this, the treatment of fractured base is directed to the cerebral condition, and does not differ from that usually applied to head injuries, viz., cold to the shaved head (preferably by means of Leiter's tubes), a smart calomel purge to start with, low diet, and absolute quiet in a dark room. In the absence of signs of cerebral irritation or inflammation (viz., increased rapidity of pulse, persistent headache, giddiness, etc.), the patient may be allowed to sit up in bed at the end of a week, and his diet is gradually increased; but he should not be allowed to get out of bed for a fortnight, and even then must keep very quiet, and not think of returning to work for four or six weeks

3. **Depressed or Punctured Fractures** usually involve the vault of the cranium, and are due to direct violence, either from a fall or blow, causing a simple or compound fracture, or from a penetrating injury occasioning a punctured fracture. In both cases there is often a considerable amount of comminution.

It is quite possible for the outer table to be broken and depressed, without any injury to the inner, where an air cavity exists in the bone, or if the diploe is very thick; thus, the bone may be driven in over the frontal sinus without injury to its inner wall, or the mastoid may be similarly affected. The inner table has also been broken, and fragments even separated, as a result of a simple depression without fracture of the outer table; this rarely occurs in adults, but is not uncommon in children. Amongst the latter, it is also possible for a considerable depression to exist without any fracture of the inner table.

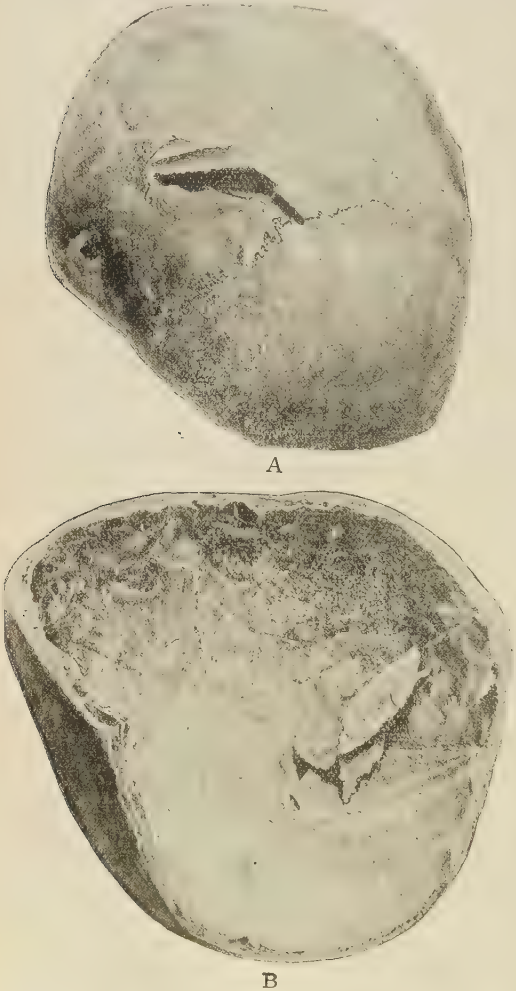

Fig. 361.—Depressed Fracture of Skull seen from Without and from Within. (King's College Hospital Museum.)

More usually both inner and outer tables are involved, and when such is due to force reaching it from without, the inner table is always more damaged than the outer, especially in the punctured variety (Fig. 361, A and B). When, however, the force is applied from within, as by a bullet which has traversed the brain, the outer table suffers more than the inner. The causes of this condition are similar, from whichever side the force comes, but need only be considered when the violence acts from without. (*a*) The inner table is less supported than the outer, having merely the soft brain and dura mater within, and hence is extensively splintered, just as a nail driven through an unsupported piece of wood causes ripping up of its under surface. (*b*) The loss of momentum of the fracturing body will assist this; the greater the momentum of a bullet, the more cleanly it cuts, a smaller momentum breaking or splintering rather than cutting; of course, a considerable amount of force is expended in penetrating the outer table. (*c*) The débris caused by the injury to the outer table will add to the bulk of the penetrating body, and its wedge-like action still further increases the injury to the inner table. (*d*) All force tends to radiate and diffuse itself from the spot struck, and hence, if the outer table is first injured, the force will be disseminated over a more extensive area of the inner.

The **Symptoms** and **Signs** arising from a depressed fracture vary widely in their nature, and are partly due to the injury inflicted on the bone, partly to that sustained by the brain, whilst the infection or not of the wound is of the gravest significance.

Locally, when an external wound is present, one sees blood or cerebro-spinal fluid escaping, or even brain substance protruding. The damage to the bone may be seen or felt, and the extent of the depression or comminution thus ascertained. When there is no external wound, a hæmatoma of variable size forms under the scalp, more or less obscuring the fracture. The character of the lesion is a matter of considerable importance from a prognostic point of view. When the bone shelves evenly in all directions, a *pond* or *saucer* fracture is said to be present, and such is tolerably amenable to treatment; when, however, the depression is sudden and complete, the detached portion lying below the level of the rest of the bone, it is termed a *gutter* fracture, and the prognosis is increasingly grave. The two forms are, however, often associated. Necessarily, considerable variations are met with in this type of fracture, according to the nature of the injury and the means by which it was inflicted. Thus, if it is due to a fall on the vertex, there is often a ragged, irregular scalp wound, through which the depression can be seen or felt; if caused by the puncture of a sharp tool, such as a pickaxe, there is only a small external opening corresponding to the hole in the skull, in which the point of the instrument may be found embedded. A slicing cut with a sabre or hatchet produces a clean incision through the scalp, together with a linear groove in the skull, perhaps somewhat bevelled, which may or may not penetrate its whole thickness. Sometimes detached portions of the skull are raised above their ordinary level, constituting an *elevated* fracture; it is usually associated with depression of surrounding parts.

Gunshot injuries of the skull manifest any degree of severity, according to the velocity and angle of incidence of the projectile. A non-penetrating wound produces either a severe localized contusion or a depression with or without comminution. If a modern conical bullet, travelling at a high rate of speed, strikes the skull, it will probably penetrate, and possibly may traverse both sides and thus escape, doing comparatively little harm, except along its immediate track. If, however, the bullet is of an expanding type, or if it is travelling slowly, it may cause a much more serious lesion.

In a *simple depressed fracture* the patient usually suffers from concussion, followed almost immediately by compression, the latter due in part to the depressed bone, but mainly to exudation of blood and bruising of the brain; if this is at all extensive and remains unrelieved, a fatal result quickly follows. Where, however, the depression is but slight, the symptoms of compression may be absent or not marked, and the patient recovers, perhaps to become the subject of traumatic epilepsy or insanity at a later date, induced by the irritation of the dura mater and of the subjacent cortex. If the depressed fragments irritate the motor area, convulsions, spasms, or paralysis may be thereby induced.

In a *compound depressed or punctured fracture* the immediate effects are not necessarily severe, the patient perhaps not even suffering from concussion, though brain substance presents in the wound; the more limited the spot injured, the less the concussion. The explanation of this fact is that the blow has expended its force in fracturing the cranium, and hence does little harm to the brain, in the same way that a watch may receive but slight damage from a fall if the glass is broken, whilst if the latter remains intact the works are liable to suffer

Left to itself, such a fracture is sure to become *infected*, and inflammation of the bone, brain, or membranes will follow.

Septic osteitis leads to necrosis of the fragments, which may be seen lying dead and yellow at the bottom of the wound, whilst the inflammation may either spread along the diploe to the surrounding bone, causing extensive necrosis with pyæmia, or between the bone and the dura mater, leading to a subcranial abscess.

When once the dura mater has been penetrated, inflammation is liable to spread to the meninges, and then a diffuse or localized suppurative meningitis, accompanied or not with a localized suppuration of the brain, will ensue. Even if the dura mater has not been opened by the injury, the irritation of depressed spicules of bone and the presence of a purulent exudation often lead to its ulceration at a later date. If there is a free external opening, allowing a ready exit to the discharge, and thus preventing tension, the process may be quite limited, and compression of the brain or diffuse septic meningitis is avoided; but if the bones are locked together as well as depressed, and the external wound is small, retention of inflammatory products may lead to their diffusion, and the symptoms of compression will soon become evident. A hernia cerebri may also form subsequently.

When the fragments of depressed bone are early removed, even if perfect asepsis is not attained, the patient has a good chance of recovery; whilst laceration of the dura need not result in meningitis, since the opening in the subdural space can be shut off by adhesions of the arachnoid in a very short time.

When an *aseptic* condition of the wound is obtained by early interference, and depressed fragments of bone are successfully elevated or removed, the prognosis becomes much better, and the case may run an uncomplicated course towards recovery, unless some deeper cerebral lesion co-exists.

The **Treatment** of these cases has been much changed by the introduction of antiseptics, the opinion now prevalent being that a patient runs greater risks from leaving a slight depression unrelieved than by making even what may prove to be an unnecessary exploration. The object of the operation in all cases is to elevate depressed bone and to remove sharp edges of fragments which might injure the dura mater. The indications for operation may be epitomized thus:

(i.) In all punctured fractures, operate.
(ii.) In all compound depressed fractures, operate.
(iii.) In simple depressed fractures: In adults, always operate; in children, if gutter-shaped, operate; if pond-shapep, wait for symptoms, unless the fracture is a bad one.

The most debatable of these propositions is that relating to the simple depressed fracture in an adult. It may be objected that many such cases have recovered without operation, and that therefore in shallow depressions one should wait for symptoms; but, whilst the existence of such cases must be admitted, the fact remains that serious after-effects, such as traumatic epilepsy and insanity, are not uncommon sequelæ of an unrelieved depression. The operation in itself is slight, and the risk insignificant when asepsis is maintained, so that one cannot but insist that the patient should be given the benefit of an exploration, especially since one can never be certain of the amount of injury sustained by the inner table.

When an operation has once been decided on, the sooner it is undertaken the better. The scalp should be shaved and thoroughly purified. An anæsthetic may or may not be given, according to the condition of the patient. In a *simple depressed fracture* the surgeon should never incise the skin directly over the wound, but should turn down a flap to avoid the presence of a cicatrix over the lesion in the bone. Having cleared away blood-clot and exposed the fracture, some loose fragments may be exposed, and the removal of these may permit of the introduction of an elevator; if more room is required, Hoffmann's bone rongeur will suffice to enlarge the opening. If there are no loose fragments, it is sometimes possible to make an opening by sawing off a corner of bone with a Hey's saw. If neither of these plans is feasible, an opening must be made with a trephine. The centre-pin is placed upon some firm undepressed bone as near the margin as possible (Fig. 362), and a circle of bone removed. An elevator can now be introduced, the fragments prised up into position, and the condition of the inner table investigated. Care must be taken in removing loose fragments not to tear the dura mater by injudicious violence, especially is this the case when the fracture lies over one of the venous sinuses. Sufficient bone must be taken away to allow the whole of the damaged area to be examined. The bony tissue removed during the operation should be kept in warm saline solution, or may be tucked in under the flap and thereby protected. When the loss of substance is small, there is no need to replace the fragments; but when it is of considerable size, it is wise to attempt this, wedging them accurately together, so that none lie loose in the wound. An opening for drainage may be left between them, if need be. In other cases they may be chipped up into small pieces and powdered over the wound.

If the dura mater has been injured, brain substance mixed with blood may escape as soon as the flap is raised. When the bone has been dealt with, any protruding portion of cerebral material is removed, and the dura mater lightly stitched across the gap. In the majority of cases no attempt should be made to replace the bony fragments, as they would certainly interfere with free drainage; but occasionally it may be possible to replace them as indicated above, with a small opening for drainage between them. If the dura mater cannot be closed, an attempt must be made to prevent the formation of adhesions between the brain substance and the superjacent tissues by introducing a piece of sterile gold-foil (or some similar substance) between the brain and the dura mater.

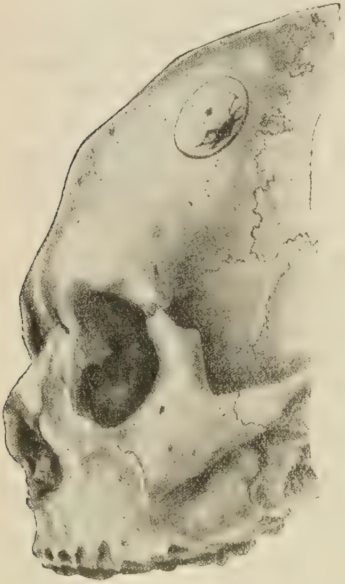

FIG. 362.—PUNCTURED FRACTURE OF SKULL, SHOWING SPOT FOR APPLICATION OF TREPHINE.

In a *compound depressed fracture* the conditions vary so much that it is only possible to give general indications for treatment. The scalp is first shaved and purified; a flap is then turned down so as to expose the bony lesion. Loose fragments of bone are removed, and depressed portions elevated. It is often unwise to replace bone in these cases, as they are probably infected, and any attempt to purify them by antiseptics would destroy their vitality. The margins of the defect are carefully cleansed, and fragments of living uncontaminated bone may be sown over the surface of the dura mater. The scalp flap is replaced, and, if possible, the original wound sutured after trimming up or excising its edges. An opening for drainage may be made through the lower part of the flap.

Exposed or protuberant brain substance is dealt with as in simple fractures, except that it is necessary to purify it by washing with some efficient antiseptic, such as 5 per cent. carbolic lotion, or a 1 in 2,000 sublimate solution; of course, drainage is essential in these cases, but the drainage-tube should be removed, if possible, in forty-eight hours, so as to minimize the chances of hernia cerebri.

In a *punctured fracture*, although the opening in the bone may be small, a large circle is removed, since the inner table is almost always extensively damaged. The centre-pin should rest on sound bone, as near the opening as possible (Fig. 362), and care must be taken to include all depressed fissures in the field of operation. If need be, the dura mater must be opened up and the brain explored.

In all cases the patient should be confined to bed with the head slightly raised on a single pillow, and the general rules suitable to head injuries followed. It is by no means certain that elevation of the depressed bone will relieve the symptoms, as they may be due to hæmorrhagic effusion into the brain which cannot be reached.

For treatment of gunshot injuries of the skull, see pp. 249 and 760.

The symptoms and treatment of the intracranial complications of head injuries are dealt with in the next chapter.

Affections of the Frontal Sinuses.

These sinuses are cavities in the frontal bones lined with a mucous membrane continuous with that of the nose. They can hardly be said to exist in children, not developing much before the age of puberty. In adults they vary much in size and shape, and are often very asymmetrical; the prominence of the superciliary ridges is no guide to their extent. A good deal of information as to these points may be gained by radiography, the rays being directed from behind, and the plates placed in front. The presence of pus and of tumours may sometimes be determined in this way, whilst transillumination (p. 801) is also useful.

Fracture of the anterior wall is not uncommon as the result of a direct blow, depression of the fragments being produced, but without cerebral complications. If the mucous membrane is torn, surgical emphysema of the scalp and face may follow, and is naturally increased on blowing the nose. In compound fractures, suppuration usually occurs, leading to septic osteitis and necrosis of the frontal bone, and, if the posterior wall is involved, to a subcranial or even a cerebral abscess. In rare cases, when the anterior wall has been destroyed, a localized collection of air may form under the skin, and remain as a permanent tumour, constituting what is known as a *pneumatocele capitis* ; it rises and falls with forced respirations. A similar condition may also result from a fracture into the mastoid cells; in either situation it should be treated by compression, or, failing this, incision.

Inflammation of the frontal sinus is caused by extension of catarrh from the nose, by penetrating wounds or fractures, by foreign bodies, or it may be secondary to disease of neighbouring bones.

Acute Inflammation is usually of a catarrhal type, and produces frontal headache, tenderness and pain on pressure, both above and below the eyebrow, and a feeling of dulness or apathy. Constitutional conditions, pyrexia, etc., may also be present. In such cases the forehead should be constantly fomented, and the patient inhales steam from hot water to which eucalyptus and menthol have been added; rest in bed and suitable purgatives are also necessary.

Acute Suppuration of the sinus is generally traumatic, and then is liable to extend into the frontal bone, giving rise to an acute osteo-myelitis, which may spread rapidly. The posterior wall of the sinuses is extremely thin, so that the membranes of the brain are easily invaded, and an abscess may develop in the frontal lobe. Occasionally extension of mischief to the cavernous or other venous sinuses may follow.

The case must be treated by laying the cavity open and draining it. For this purpose a curved incision is made along or immediately below the eyebrow, and the soft parts stripped from the bone, through which a sufficient opening is made with a gouge close to the middle line; the pus or mucus is removed, and the passage into the nose explored and dilated so as to allow of free drainage. The cavity is syringed out for some days, and the wound usually closes readily, although a fistula occasionally remains. A median vertical incision is useful if there is any doubt as to which sinus is involved, or if both are affected.

Should acute osteo-myelitis develop, vigorous measures are necessary. In a case of this type under treatment incisions were made along each eyebrow from the middle line and a vertical one extending from the hair to the root of the nose. The flaps thus formed were thrown back, the sinuses freely opened, and their anterior walls entirely removed: a large amount of the frontal bone was also taken away until healthy diploe free from purulent infiltration was reached. During the process the posterior wall of the right sinus was removed, and a large cerebral abscess opened. The patient made a good recovery, although a considerable amount of dead bone had subsequently to be taken away.

Chronic Empyema of the frontal sinus may be the outcome of an acute catarrhal inflammation, or may be chronic from the first, extending upwards from the nose. Pus is constantly found in the anterior portion of the middle meatus, and its discharge is not much influenced by the position of the head. Frontal headache is often complained of, and there may be some localized tenderness on pressure. If the infundibulum becomes blocked, the pus may collect and lead to distension of the cavity, the bony walls gradually thinning and yielding before the pressure. A similar condition occasionally results from distension of the cavity with mucus (*hydrops*). When the walls are sufficiently thinned, ' eggshell crackling ' may be noticed. Owing to its anatomical relations to the lower orifice of the infundibulum, the maxillary antrum is often involved secondarily, if it has not been already infected.

In the **Treatment** of chronic empyema external operation must, if possible, be avoided, since experience has shown that it is associated with a definite mortality, due to acute osteo-myelitis. The intranasal condition is carefully treated; the anterior portion of the middle turbinal is removed so as to give a better exit to the discharge, and a skilled rhinologist is usually able to pass a tube up the infundibulum and wash out the cavity. Should these measures fail to give relief, and should urgent symptoms appear, then the cavity must be opened as described above, and a tube passed through into the nose, the external wound either being closed at once (Luc), or left open for a few days and packed with gauze.

The chief **Tumours** growing from the frontal sinuses are mucous cysts or polypi, and ivory osteomata; they may also be involved in diffuse sarcoma or carcinoma, but the disease is then not limited to the sinus. The main symptoms and signs result from distension of the walls of the cavity, which may yield anteriorly, causing a large frontal swelling; or the posterior wall is absorbed, leading to cerebral compression; or the upper wall of the orbit may be depressed, causing dislocation of the eyeball, and possibly blindness (Fig. 57, p. 210). Tumours which have attained considerable dimensions can rarely be removed, death then resulting from cerebral compression; but occasionally bony masses may necrose, and become loosened by suppuration around them, and in a few cases they have been taken away successfully.

CHAPTER XXVII.

AFFECTIONS OF THE BRAIN AND ITS MEMBRANES.

Cranio-cerebral Topography.

IT is scarcely necessary or desirable in a students' manual to deal exhaustively with this subject. The main facts can alone be referred to, and larger text-books of operative surgery or surgical anatomy referred to for further details.*

The *Fissure of Rolando* may be found topographically by the following methods: (*a*) The upper extremity of the fissure corresponds to a point 1 centimetre (or $\frac{2}{5}$ inch) behind the centre of the line extending from the fronto-nasal suture to the external occipital protuberance. The direction of the sulcus is downwards and forwards at an angle of about 67° to the middle line. This may be indicated by laying a half-sheet of letter-paper over the skull, the long side corresponding to the middle line, and with its centre over the upper limit of the fissure; the anterior half is now folded over obliquely from this point, leaving an angle of 45° between the front of the paper and the middle line of the skull; and then the same process is again repeated, bisecting the angle and leaving one of about 67°, so that the anterior limit of the folded paper corresponds to the line of the fissure, which is about $3\frac{3}{8}$ inches in length. A 'Rolandometer,' consisting of two strips of flexible metal united at the appropriate angle, is now sold by many instrument-makers. As a general rule this 'Rolandic line' crosses the fissure about its centre, being in front of the fissure above and a little behind it below; but it is sufficiently accurate for practical purposes. (*b*) A less exact method is that defined by Dr. Reid, the measurements for which are all worked from the so-called Reid's base-line, which is one drawn on the skull from the lower margin of the orbit backwards through the centre of the external auditory meatus, reaching the middle line behind just below the occipital protuberance (Fig. 363). From it are drawn upwards two perpendiculars, one (CD) corresponding to the small depression in front of the external auditory meatus, the other (EF) to the posterior border of the mastoid process. The fissure of Rolando extends from the upper limit of the posterior vertical line to the point where the anterior line intersects the fissure of Sylvius.

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* For a review of the relative accuracy of various methods, see a paper by Berry and Shepherd, *Brit. Med. Journ.*, p. 1382, November 19, 1904.

To map out the *Fissure of Sylvius*, (1) Reid utilizes a line drawn from a point $1\frac{1}{4}$ inches directly behind the external angular process of the frontal bone (Fig. 363, A), and about the same distance above the zygoma, to a spot $\frac{3}{5}$ inch below the most prominent part of the parietal eminence. The undivided portion of the fissure is represented by the first $\frac{3}{4}$ inch, and from here the anterior limb (Sy. A. Fiss.) rises vertically upwards for about an inch, whilst the posterior limb extends backwards for the rest of the line. If prolonged to the middle line behind, it indicates with tolerable accuracy the situation of the parieto-occipital fissure (P. O. Fiss.). Careful investigation, however, has shown that no great reliability can be placed on this method.

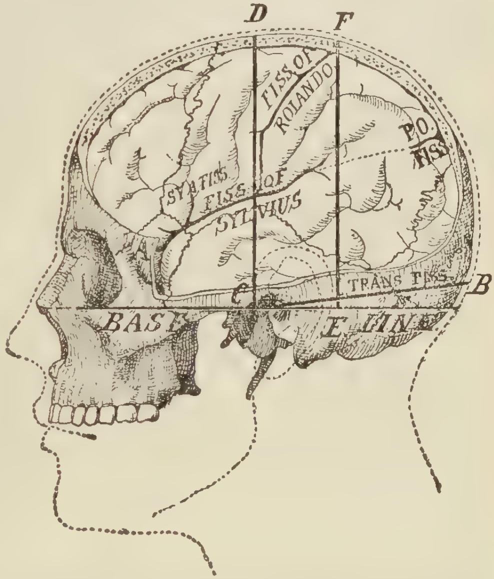

Fig. 363.—Diagram of Head to indicate Method of finding the Fissures of Rolando and Sylvius by Reid's Method.

Sy. A. Fiss., Anterior branch of Sylvian fissure; P. O. Fiss., parieto-occipital fissure; Trans. Fiss., transverse fissure along line of tentorium; A, external angular process of frontal bone; B, occipital protuberance; CD, anterior perpendicular in front of tragus; EF, posterior perpendicular through back of mastoid process.

(2) Hare and Thane suggest the following measurements, which in the majority of adult skulls may be looked on as substantially accurate: To find the *Sylvian point* (*i.e.*, the point of bifurcation of the fissure), a line is drawn horizontally backwards from the fronto-malar suture for a distance of 35 millimetres, and from the posterior end of this a vertical line upwards for 12 millimetres; the upper extremity of this line is the Sylvian point. The posterior limb of the Sylvian fissure is indicated by a line drawn backwards from the fronto-malar suture through the Sylvian point to the lower part of the parietal eminence.

The external limb of the *parieto-occipital fissure* corresponds almost exactly to the lambda.

(3) Krönlein's method (Fig. 364) of locating the Rolandic and Sylvian fissures is useful, and not so complicated as many others. Two horizontal lines are drawn round the skull, one, the lower (AB), through the infra-orbital border and upper margin of the external auditory meatus; the other (CD) above it and passing through the supra-orbital margin. Perpendiculars are carried upwards from the lower of these (1) through the centre of the zygoma, (2) through the condyle of the lower jaw, and (3) at the posterior border of the mastoid process. The posterior of these is prolonged to the vertex at R; the anterior cuts the upper horizontal line at S; and the middle perpendicular intersects the line joining S and R at R′. The angle RSD is finally bisected by a line SS′ which represents the posterior limb of the Sylvian fissure, whilst RR′ corresponds to the fissure of Rolando.

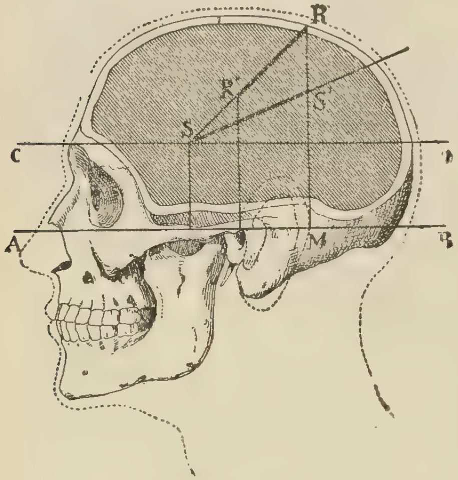

FIG. 364.—KRÖNLEIN'S METHOD OF LOCATING THE FISSURE OF ROLANDO (RR′), AND THE POSTERIOR LIMB OF THE FISSURE OF SYLVIUS (SS′).

Methods of Opening the Cranium.

In the old days but one instrument was employed for this purpose, viz., the trephine; but our increasing knowledge of cerebral lesions and the security given by aseptic methods have necessitated a considerable elaboration in the methods of operating on the cranium.

1. Simple *trephining* is still employed in dealing with many traumatic lesions where an extensive exposure of the brain is not required. The modern trephine is often fitted with a solid metal handle to render sterilization easy, and the crown is usually bevelled and not straight, so as to check the liability to slip inwards and wound the dura. The scalp is incised and turned aside by raising a flap which has its base downwards, so as to ensure its vitality. Bleeding is abundant, and it may save time to prevent this by encircling the base of the scalp with rubber tubing drawn tight and fixed by a pair of Spenser-Wells forceps. The pericranium is stripped from the bone, and the trephine applied with the centre-pin projecting. As soon as a well-marked groove has been made, the centre-pin is withdrawn or removed, and the instrument carried through the cranium. An increased flow of blood will often indicate when the diploe is reached, and care must be taken not to injure the dura.

To this end the groove in the bone is carefully examined from time to time by a flattened probe or the blunt end of a needle, and the more so when the operation is undertaken in a region where the bone is known to be of irregular thickness. The disc is removed by an elevator. Considerable bleeding sometimes takes place from the section of the bone, but can usually be controlled by crushing the spot with powerful forceps, or by rubbing in Horsley's wax (carbolic acid, 1 part; oil, 2 parts; wax, 7 parts). If the opening is not sufficiently large, it may be increased by the bone rongeur, Hey's saw or cutting pliers, or even by the trephine.

2. In many cases of cerebral abscess the trephine is unnecessary, as the causative focus (*e.g.*, mastoid disease or frontal sinus empyema) can be opened up, and the cranial cavity reached by removing portions of bone with a gouge. When well inside the skull, a bone rongeur or de Vilbiss' punch will suffice to enlarge the opening. Even when the cranium is intact, the gouge is used by some in preference to the trephine to make the first opening.

3. When a considerable area of the brain needs exposure, as in the case of cerebral tumours, various plans are adopted:

(*a*) Some surgeons utilize a large 2-inch trephine, but this is obviously undesirable owing to the irregular thickness of the skull, and the difficulty which attends the equal deepening of the groove in all directions over such a large circumference.

(*b*) When there is no likelihood of being able to replace the bones, a small trephine hole and enlargement by the rongeur should be adopted.

(*c*) Of late, however, some form of Wagner's osteoplastic method has been chiefly used. In this a flap of scalp tissues is turned down together with the underlying bone, laying bare the dura mater. Some surgeons divide the bone along the line of incision with a chisel and wooden mallet; this requires great care and skill, as the dangers of concussion of the brain from such a plan are not to be overlooked. Others use a circular saw; but probably the simplest way is to make four small trephine openings at the corners of the flap, and connect these either by the use of a Hey's saw, or by a Gigli saw (*i.e.*, a piano-wire with a screw-thread turned on it, and with handles attached at each end), passed by means of a probe under the bone from one opening to another, or by the use of a rongeur on two sides, whilst the upper end is sawn through by a Hey's saw set on the slant, so that the incision is bevelled, thereby preventing the bone from slipping in when replaced, and the base is divided by a Gigli saw. This procedure is a serious one, attended by considerable shock and hæmorrhage, and therefore is often undertaken as a preliminary measure a week or ten days before the lesion in the brain is attacked.

Lumbar Puncture in Cerebral Lesions.

The removal of cerebro-spinal fluid from the lumbar region has been much employed, since Quincke first suggested it in 1891, in connection with affections of the cranium and its contents, and both diagnostically and therapeutically it is of the greatest value.

The method of withdrawal is quite simple. A stout antitoxin or exploring needle should be selected and sterilized by boiling, and the skin in the region of the third and fourth lumbar interspaces (the spinous process of the fourth vertebra is on a line joining the iliac crests) is to be carefully purified. The patient sits or lies with the body well flexed. The needle is then inserted in the fourth interspace, either in the middle line, or a third of an inch from it; it must be pointed forwards, with a very slight inclination upwards. In most cases the needle will go straight into the spinal canal below the termination of the cord, and the fluid will escape. If bone is ncountered, it is advisable to withdraw the needle and re-insert it at a slightly different angle. In cases of repeated failure the third interspace may be tried. Under ordinary circumstances the fluid escapes quietly, drop by drop; but in cases of increased tension it may gush out freely.

Normal cerebro-spinal fluid* is slightly alkaline and as clear as water, with a specific gravity of 1006 to 1008; it contains a trace of globulin and of a copper-reducing substance, and perhaps a few lymphocytes. It is calculated that from 100 to 130 c.c. are present in the normal adult, but the amount is readily increased where free exit is possible, as in fractures of the skull, when quantities of the fluid escape. It is probably secreted by the choroid plexuses, and removed by absorption into the venous sinuses. It not only surrounds the brain and spinal cord, but occupies the ventricles, and passes into direct communication with the lymphatics of the cortex and of the peripheral nerves.

In *acute meningitis*, due to organisms other than the tubercle bacillus, the fluid is turbid and contains much albumen. Many cells are present, most of which are polynuclear leucocytes. Bacteria may be detected by suitable methods of staining or by cultures.

In *tuberculous meningitis* the fluid is almost clear, and contains a slight excess of albumen and of lymphocytes. Tubercle bacilli are rarely found. In all varieties of meningitis the fluid is secreted under pressure, and usually issues from the needle in a stream.

In *cerebral abscess* and *lateral sinus thrombosis* the fluid is normal, but may be under excessive pressure.

In *fracture of the base of the skull* or of the *spinal column*, and in *injuries of the surface of the brain*, blood usually appears in the cerebro-spinal fluid within a few hours of the accident and is intimately mixed with it.

The **Therapeutic** value of this procedure has not been so fully recognised as its use in diagnosis. In many cases of meningitis the coma is due mainly to excessive cerebro-spinal fluid, and if the amount of this can be diminished the symptoms often abate. The value of lumbar puncture will, therefore, depend on whether or not it is possible to influence the intracranial tension thereby, and that, in turn, is dependent on the situation and character of the adhesions present. The puncture must, therefore, be obviously experimental, as one can never be certain as to the adhesions; but it is a simple proceeding, and may well be employed in all cases of meningitis, in the hope that some good may follow. In traumatic conditions it may be useful when the lesion is not very serious, and the pressure on the brain not hopelessly exaggerated. In cerebral tumours it must be employed with the greatest caution, if at all, as fatal results have followed the removal of a comparatively small amount of fluid owing to undue pressure on the base thereby induced.

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* For further details, see Sir David Ferrier: 'The Cerebro-Spinal Fluid in Health and Disease,' *Lancet*, October 18, 1913.

It is also possible to introduce drugs within the spinal theca after lumbar puncture, *e.g.*, antitetanic serum in tetanus, solutions of magnesium sulphate in tetanus, or of sodium bromide in delirium tremens. Attempts have also been made to influence by this means parasyphilitic nervous affections where the cerebro-spinal fluid remains positive to the Wassermann reaction in spite of general medication; such treatment has not yet met with much success.

General Conditions of the Brain after Head Injuries.

Concussion of the Brain, or stunning, is a clinical condition characterized by a more or less complete suspension of its functions as a result of injury to the head, which leads to some commotion of the cerebral substance, and may or may not be associated with hæmorrhage. It varies with the severity of the cause from a slight momentary giddiness and confusion of thought to the most complete insensibility, and is closely allied to shock, from which it is often distinguished with difficulty.

In fatal cases, one finds on post-mortem examination merely the same conditions as obtain in shock, viz., engorgement of the lungs, viscera, and the right side of the heart, whilst the brain presents some lesion of varying severity, from mere punctiform ecchymoses to actual disintegration and disorganization. The symptoms can scarcely be attributed to the injury itself or to a reflex stimulation of the vagus, as they often bear so little proportion to the degree of mischief. Duret's theory is probably correct, which attributes the phenomena to stimulation of the restiform bodies in the medulla by the sudden displacement of cerebro-spinal fluid owing to the temporary driving in of the skull by the injury. Apparently the fluid is forcibly expelled from the lateral ventricles along the iter to the fourth ventricle, the roof of which has been ruptured, the floor bruised, or the iter torn in experiments confirming the theory. The grouping of the vital centres about the floor of the fourth ventricle will explain the gravity of the symptoms often present.

The **Symptoms** vary considerably in degree, but in a well-marked case the stage of concussion is evidenced by unconsciousness, more or less complete, although the patient can sometimes be roused by shouting; he lies on his back, with the muscles relaxed and flaccid;

the eyelids are closed, and the conjunctivæ may be insensitive; the pupils vary, but are equal and often contracted, usually reacting to light; but in bad cases they are dilated, and do not contract when light is admitted. The surface of the body is pale, cold, and clammy. The respirations are slow, shallow, and sighing, whilst the pulse is rapid, weak, fluttering, and scarcely sensible to the fingers; the temperature is at first subnormal; the sphincters are relaxed, with perhaps unconscious evacuations from both bladder and bowel. The reflexes are present in the milder cases, though sluggish; in the more severe they may be entirely absent.

This condition may last for a considerable time, and then pass slowly into more profound unconsciousness and death, or be followed by the phenomena of inflammation, compression, or cerebral irritation. In the simpler cases, however, *reaction* soon begins to manifest itself. The patient is presumably put to bed, and warmth carefully applied to the extremities. The first sign of reaction is probably a slightly increased rate of both breathing and pulse, whilst he may be able to tell his name and address; sometimes he turns on his side, and pulls the bedclothes up to his face, since he feels cold and chilly as a result of the cutaneous anæmia. Gradually he becomes more and more rational, and the functions of both mind and body are restored, reaction being fully established by the occurrence of vomiting, due to a condition of cerebral hyperæmia following the anæmia. Probably he suffers from headache for some days, and a slight amount of fever will follow; but this passes off, and leaves the patient either quite well, or with a somewhat irritable brain requiring prolonged rest. Subsequent events may, however, prove that more mischief has been done than appears at first. Thus, some special function of the brain may be permanently lost or impaired, such as memory, hearing, or vision; a patient may forget the names of places or persons, or may lose all memory of time; speech may become defective or stammering, or a certain amount of asthenopia (weakness of vision) may supervene. Such individuals are very liable to develop signs of mental instability, and even delusional insanity or melancholia, if placed in positions of responsibility or strain. Others seem to suffer from a general loss of nerve tone (neurasthenia), rendering them incapable of fulfilling their ordinary duties in life. In all the more severe cases there is a complete lapse of memory as to the accident, and even as to the events which preceded and followed it, extending sometimes to a fortnight or more, and perhaps including a period during which the patient was apparently quite rational.

The **Treatment** of concussion very closely resembles that of shock, viz., the patient is at once put to bed, with the head low, and is covered with warm blankets; hot-water bottles may be applied near the extremities, and friction to the surface. Any needless stimulation must be avoided for fear of exciting hæmorrhage; an enema of hot coffee may be given, or, if *in extremis*, brandy, or a hypodermic injection of strychnine. A good purge, such as 5 grains of calomel, or a drop or two of croton oil on sugar, should be administered after reaction in the milder cases, but whilst still unconscious in the graver forms. It is most important that the patient be kept quietly in bed for at least ten days or a fortnight after a moderately bad concussion, and free from all sources of worry and irritation, even though he feels quite well. The diet must be restricted, and the bowels kept open. 'Make haste slowly' is here a golden rule.

When the unconsciousness is prolonged, and no signs of fracture of the cranium exist, lumbar puncture should be employed, and may be most beneficial. Thus, a lady who had attempted suicide by throwing herself from a window lay for two or three days on the borderland of unconsciousness, frequently relapsing into a comatose state. Lumbar puncture resulted in the drawing off of some drachms of blood-stained fluid, and at once restored her to complete consciousness, which was not again lost. Should this treatment fail, the head should be shaved, and an icebag or Leiter's tubes applied; the bowels are opened regularly, and the state of the bladder attended to; the room must be kept dark and quiet, the attendants making as little noise in walking and talking, etc., as possible; sufficient nourishment must be given either by a spoon if the patient can thus take it, or by nutrient enemata or a nasal tube.

Cerebral Irritation.—By cerebral irritation is meant a clinical condition which sometimes follows concussion, characterized by great irritability of both mind and body. It usually results from blows or falls on the temple, forehead, or occiput, and is probably due to a superficial laceration of the brain, possibly in the frontal region, and to the hyperæmia caused by its subsequent repair.

The **Symptoms** are very characteristic, and usually manifest themselves two or three days after the injury, though sometimes earlier. The patient lies on his side in a condition of general flexion, the back arched, the legs drawn up to his abdomen with the knees bent, and the hands and arms drawn in. He is restless, and may toss about, but never extends himself fully or lies supine. The eyes are closely shut, and he resists all attempts to open them; the pupils are contracted; the temperature is usually a little raised, but the surface of the body and head are both cool; the pulse is quiet but weak; the sphincters are usually in a normal condition, and the excreta are often passed in the bed, but the bladder may occasionally need to be emptied by catheter. In some mild instances the patient may get up to empty his bladder and then return to bed. He is by no means unconscious, but takes no heed of what is passing around, and is intensely and morbidly irritable. When disturbed, he will gnash his teeth, frown, swear, and resent the intrusion in the most expressive manner. At the end of a few days, or perhaps after a week or two, a marked alteration in the condition of the patient usually shows itself. He is less irritable, begins to stretch himself out, and with this is conjoined an improvement in both pulse and temperature. Sometimes he becomes childish, and needs to be taught the names of persons and things; at other times he is garrulous, perhaps giving a fresh story of his accident every day, but generally there is an absolute lapse of memory in this direction. Usually the brain recovers in time, but serious after-effects in the direction of chronic meningitis or mental aberration are likely to ensue.

Treatment.—The patient is kept quiet and free from noise or excitement; his diet must be light and nourishing. The head should not be too low, and Leiter's tubes may be fitted on if the patient will permit it; but it is better to omit this entirely than to apply cold intermittently. The bowels are kept well open, and possibly small doses of bromide, or even opium, may be useful. If any signs of meningeal inflammation follow, such as rise of temperature and pulse, heat of head, and great sleeplessness, blisters or leeches may be applied locally, and mercury administered internally.

Compression of the Brain.—Compression is the term given to a clinical condition due to some abnormal and excessive intracranial pressure which disturbs the functions of the brain. In the earlier stages a displacement of cerebro-spinal fluid from the cranium to the vertebral canal, and increased absorption in various directions, may relieve the symptoms; but as the pressure increases, the brain substance itself suffers, the cortical centres being involved first, and the medulla last. The effect of such increased pressure is to paralyze after temporarily stimulating. When of traumatic origin, it may arise from the following causes: (*a*) Depressed bone or the presence of a foreign body, in which case the symptoms of concussion merge directly into those of compression, and usually without any interval of consciousness. It is probable, however, that in these cases the symptoms are due more to the associated hæmorrhage than to the actual cranial lesion. (*b*) Extravasation of blood within the cranium, either outside the membranes, or on the surface of the brain, or within its substance. If the bleeding is extradural, there will probably be a short interval of consciousness between the concussion and the compression; if the bleeding is cerebral, the symptoms of compression may manifest themselves at once without any interval being noticed. (*c*) It may be due to an acute spreading œdema, the explanation of which is subsequently given (p. 755). (*d*) It may arise from the pressure of inflammatory exudation or pus, in which case the symptoms are preceded by those of inflammation, and at the earliest will not manifest themselves before the third day, whilst they may be deferred for a week or two.

Compression also arises as a result of idiopathic hæmorrhage, tumours, gummata, or abscesses—*e.g.*, of middle-ear origin.

The **Symptoms** of compression are essentially those of *coma*. When the condition is well established, the patient lies on his back absolutely unconscious, and cannot be roused either by shouting or shaking. His *breathing* is slow, laboured, and stertorous, the lips and cheeks being puffed in and out. The stertor arises from paralysis of the soft palate, and the puffing of the cheeks from paralysis of the facial muscles. In the later stages the respirations become irregular, and take on the Cheyne-Stokes type. Gradually breathing becomes more shallow and difficult, and death finally arises from cessation of the respiratory act. The *pulse* is full and slow at first from irritation of the vagus and vasomotor centres, but later on becomes rapid and irregular, owing to increased pressure upon and exhaustion of these medullary centres. The *surface* of the body may either be cool, hot, or perspiring; the *temperature* similarly varies, often being low in the early stages and higher at a later date. Not unfrequently the fatal end is associated with marked hyperpyrexia. In some cases where the compressing force is unilateral, there may be some difference of temperature on the two sides of the body. The *pupils* become dilated without responding to light, but vary according to the degree of compression and the situation of the compressing agent. If the cerebral pressure is equally diffused, both pupils first contract, and then gradually dilate and become reactionless; but if one hemisphere is affected more than the other, the pupil on that side passes rapidly through these changes, whilst on the opposite side they are not developed until later. Thus, it is a common thing to find the pupils unequal in size, and reacting differently to light. The whole body in the later stages is in a condition of *motor paralysis*, but at an earlier period of the case there may be some difference on the two sides, if the lesion is unilateral; thus, if the left side of the brain is primarily affected, a right-sided hemiplegia is likely to be present at a time when the muscles on the left side can still respond to cerebral stimuli. A localized compression involving the motor area may lead to convulsions in the corresponding group of muscles. The bladder is paralyzed, and hence retention ensues, whilst the sphincter ani is relaxed, and fæces pass involuntarily, although marked constipation is usually present.

The symptoms in some cases are ushered in by severe pain or headache, which is partly due to pressure upon and tearing of the dura mater, and partly to the altered vascular conditions of the brain; the brain substance itself is not sensitive, and hence the pain is not directly referable to any lesion of or pressure upon it. Naturally, the clinical picture is modified according to the cause of the compression, even as the course of the case varies widely according to whether or not the compressing agent can be removed by the surgeon, or absorbed by natural processes.

The **Diagnosis** of coma from compression, when a complete history of the case can be obtained, is often easy, and, indeed, the whole clinical aspect may be so typical that no question as to the cause of unconsciousness can be raised. But when a person is found in the streets unconscious, and no history either of the patient or of an accident is obtainable, and no serious lesion of the skull is present, the diagnosis is often extremely obscure, since coma may be due to many other causes, *e.g.*: (*a*) Cerebral lesions, such as apoplexy, whether the result of hæmorrhage, embolus, or thrombosis; or it may be the consequence of a preceding epileptic fit, or due to a rapidly spreading œdema in cases of cerebral tumour or abscess. (*b*) Various toxic agents may induce coma; they may be introduced into the system from without, as in the case of alcohol, opium, or other narcotics, or may be developed within the body, as in uræmia or diabetic coma. (*c*) Heatstroke or exposure to cold may also lead to unconsciousness. In the latter case there can be but little doubt as to the cause, since the patient is cold, pale, and in a state of severe prostration; in the former the diagnosis may for a time be doubtful. (*d*) Lastly, it must not be forgotten that two or more of these conditions may co-exist. Thus a drunken man may fall and break his skull, and then the smell of liquor in his breath may lead to an erroneous diagnosis.

It is therefore evident that a very careful examination of the patient is required before any conclusion can be arrived at as to the cause of the coma, and it is often impossible to make an immediate diagnosis. In such cases the patient should be carefully tended and watched, and not shut up for the night in a police-cell without attendance.

The following points should always be observed in the examination: (1) A rapid note should be made as to the surroundings of the patient—whether there is blood or vomit near him, how the body is lying, and the nature of the ground. (2) The depth of the coma should be ascertained, and, if possible, the man should be roused, and asked to give an account of himself. (3) A most thorough and complete investigation should be made as to his condition. His skull must be first examined, to settle if possible whether or not a fracture is present; the surface temperature of the body is noted, as also the character of the pulse and respirations. The tongue should be looked at, as it is often bitten in an epileptic fit, and the smell of the breath should also be noted. Be it remembered that the smell of alcohol in the breath is not sufficient warrant in itself to diagnose merely drunkenness, as the alcohol may have been given after the accident to revive the patient. The condition of the pupils may throw some light on the case; in opium-poisoning they are small and equal, a condition also seen in hæmorrhage into the pons; in alcoholism they are often dilated and fixed, but vary considerably in different cases. The amount of power and the state of the reflexes are then observed, any inequality probably indicating a unilateral lesion in the brain. The urine must be drawn off, and carefully examined for albumen and sugar. (4) In dubious cases, and especially where there is any suspicion of drunkenness or poison, the stomach should be emptied and washed out. (5) Finally, if the cause is still uncertain, the patient should be put to bed and carefully watched.

The **Treatment** of compression must be, where possible, directed to removing the cause. When it is due to depressed bone or a foreign body, immediate operation is required; collections of pus should be opened, and blood-clots removed. Failing such measures, and if lumbar puncture gives no relief, the treatment of the condition resolves itself into keeping the patient quiet, with the head low and cool, the room dark and noiseless, the bowels open (using croton oil on sugar, or enemata, for this purpose), and the bladder empty. The patient may have to be fed by the rectum, and if the breathing or pulse is very laboured, and cyanosis begins to show itself, venesection may be advisable. Considerable interference with the respiration arises from falling back of the tongue, as often occurs in profound anæsthesia during surgical operations, and if due to this cause the head may be rolled over to one side, or the tongue pulled forwards.

Laceration of the Brain.—Injuries to the brain and its membranes are frequent complications of head injuries, and all the most serious results of these accidents arise from this source. They are produced in many different ways, and cause varied symptoms; but the most important distinction to draw is between those wounds which communicate with the exterior and those which do not.

I. **Non-penetrating Wounds of the Brain** result from blows and falls, which may or may not produce simple fissured or depressed fractures of the skull, but not unfrequently the most serious cerebral symptoms follow injuries in which the bones do not participate. In depressed fractures the brain is usually most contused or torn immediately below the injured spot; but in cases where there is no depression, the greatest mischief is frequently found at a point exactly opposite to that struck (point of *contrecoup*), whilst the local bruise may be much slighter. Thus, in the case of one of our students who, in an epileptic fit, fell, striking the left occipital region on a stone pavement, we found *post-mortem* a fissured fracture at the spot struck and a bruise on the left occipital convolution, whilst the anterior portion of the right frontal lobe was severely contused, and, indeed, disintegrated. The explanation of this fact is that the force of the injury is transmitted to the brain substance in a wave which concentrates its violence against the opposite side of the skull. In very sharp sudden localized blows, as from a spent bullet, local bruising of the subjacent brain may be alone produced.

Pathological Anatomy.—The *immediate* effects of such an injury vary considerably. There may be a mere bruise, evidenced by a few points of extravasation, on the surface or in the gray matter; or the more superficial parts of the brain may be totally disintegrated and mixed with clots; or, if laceration has occurred, clots may be found adhering to the injured spot, or extending from it widely into the subarachnoid space, or even, under rare circumstances, into the lateral ventricle. The *later* effects in cases where the wound does not communicate with the exterior are mainly those of inflammation or degeneration. Soon after the accident considerable exudation follows, causing the ecchymosed brain substance to swell and become œdematous; this may speedily subside, but in the more serious cases a *spreading œdema* may be caused, owing to the pressure of the swollen tissues upon the superficial veins in the pia mater; the circulation in these is hindered, and increased exudation follows, leading to general cerebral pressure and even death, a consequence hastened by the excess of cerebro-spinal fluid usually induced by the process. Under such circumstances the greater part of the brain is œdematous and glistening, the injured area being yellowish-red in colour, with evident points of extravasation scattered through it. Still later, degeneration of the brain substance may follow owing to the disturbance of its circulation, and is indicated by the presence of a pulpy yellowish mass, soft enough to be washed away by a stream of water, and containing fat globules and granular cells, with débris of nerve fibres (*yellow softening*). If the area involved is small and unimportant, the patient may recover, the softened tissue being absorbed, and replaced by a scar; if large or implicating important centres, death or paralysis must ensue. In cases of laceration of the brain which recover, a tough depressed cicatrix is formed, usually adherent to the membranes, and containing hæmatoidin crystals, whilst extravasated blood may be organized into a dirty brownish lamina, adherent to the pia mater, or into an arachnoid cyst.

Clinical History.—The symptoms necessarily differ with the severity and locality of the lesion.

Whenever concussion occurs after a head injury, and the patient recovers slowly from it, the surgeon will rightly suspect contusion or laceration of the brain. In the slighter cases recovery is often inaugurated by an attack of vomiting, and this is followed by a rise of temperature to about 100° F. for a few days, whilst the patient complains of fixed pain and headache, which under suitable treatment may entirely disappear. Some impairment of sense or function may, however, persist.

More serious lesions give rise to various symptoms resulting from hæmorrhagic effusion, and these will manifest themselves either at once or within twenty-four to forty-eight hours of the injury. Thus, if the phenomena of compression supervene at once, without any interval of consciousness, a diagnosis of depressed bone or a serious hæmorrhage into the cerebral substance may be safely made. If, on the other hand, the patient rallies for a time before the incidence of compression phenomena, an extradural hæmorrhage from the meningeal vessels or venous sinuses may be suspected, or a rapidly spreading œdema.

Hæmorrhage into the cortex is characterized by irritative or paralytic phenomena, which vary with the cortical area involved. The degree of unconsciousness depends on the amount of the hæmorrhagic effusion.

In the *Upper and Middle Frontal Convolutions* neither motor nor sensory symptoms are noted, but cerebral irritation and subsequent weak-mindedness are likely to follow, especially if the left side is involved; lesions to the right frontal lobe do but little harm to a right-handed individual. Apparently, the intellectual faculties are limited to one side of the brain, in the same way as the power of speech.

Wounds of the *Third Left Frontal Convolution* lead to motor aphasia—*i.e.*, the inability to produce or articulate words, in right-handed individuals; in left-handed people wounds of the right side have a similar result. Injury to the opposite convolution has no effect. If only one side is damaged, the other convolution can after a time be educated so as to take on the function of the damaged region.

Hæmorrhage into *the Motor Area* (Fig. 365) results in localized convulsions or paralysis, according to the degree of mischief. If the bleeding is progressive, a regular extension of the convulsions may be witnessed, the movements commencing, perhaps, in some region which is at the time incapable of voluntary movement, and spreading to other parts of the body. Thus, if bleeding is occurring into the cortical centres for the face on the left side of the brain, paralysis of the right side of the face may be present, and it is here that the convulsions will start, spreading regularly to the right side of the neck, arm, and leg, and then involving the left leg, arm, and side of the head in order, finally becoming general, as in an epileptic fit. After each convulsion the paralysis is found to have spread.

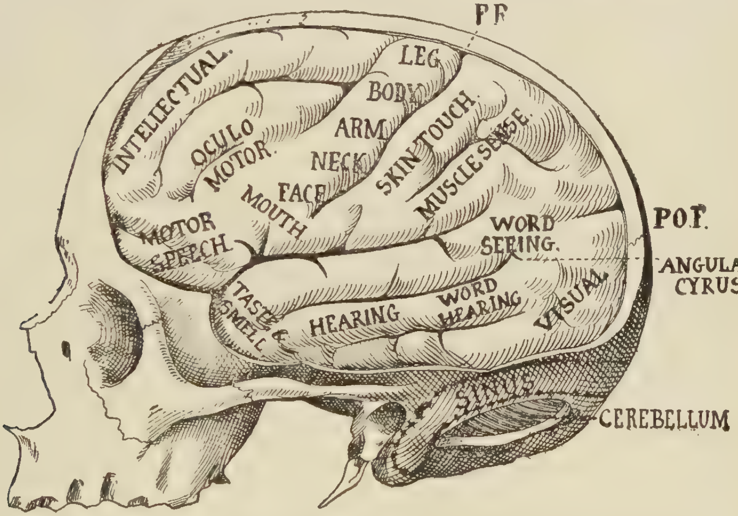

FIG. 365.—DIAGRAM REPRESENTING THE FUNCTIONS OF THE CEREBRAL CORTEX.

F. R., fissure of Rolando; P. O. F., Parieto-occipital fissure

It is sometimes very difficult to diagnose between a true cortical hæmorrhage and one which extends diffusely over the cortex in the subarachnoid space from the rupture of a vein in the pia mater. In the latter, however, the symptoms develop earlier, the paralysis is less marked, and the convulsions are less regular, though perhaps more generalized.

An irritative lesion of the motor area for the head and eyes causes a conjugate deviation of the eyes towards the other side; a destructive lesion causes both eyes to be deflected towards the injured side.

Wounds of one *Occipital Lobe* may cause a temporary hemiopia, but no persistent loss of vision, unless the angular gyrus is also destroyed. Lesions of the latter region are always associated with permanent disturbances of vision.

The *Upper Temporo-sphenoidal Lobe* contains the cortical auditory centre, and lesions in this region cause deafness. The sense of smell is located in the anterior portion of the lower temporo-sphenoidal lobe which constitutes the uncinate process.

Injury to the *Corona Radiata* leads to paralysis of the regions represented by the overlying cortex, but without convulsions or other irritative phenomena. If the corpus striatum or internal capsule is torn or involved in a hæmorrhage, coma rapidly supervenes, accompanied by hemiplegia and perhaps hemianæsthesia. Occasionally the effused blood bursts *into the lateral ventricle*, and causes a rapid rise of temperature, increasing until the patient's death, together with a very rapid weak pulse and increased respiratory rate (40 to 60 per minute).

Wounds of the *Cerebellum* cause giddiness, vertigo, and ataxy, the patient reeling about in characteristic cases, as if drunk.

A wound of the *Crus Cerebri* occasions more or less complete hemiplegia of the opposite side of the body, associated with some amount of hemianæsthesia, and total paralysis of the 3rd (oculomotor) nerve on the side of the injury.

Laceration or contusion of the *Pons Varolii*, if not immediately fatal, may lead to paralysis of the opposite side of the body to the injury, together with paralysis of the 5th, 6th, 7th, or 9th nerves, on the same side as the lesion, constituting the so-called 'crossed paralysis.' Marked contraction of the pupils (myosis) may also be present.

Wounds of the *Medulla* are usually fatal. If, however, the patient should escape, he is liable to suffer from disturbed functions of the circulatory and respiratory centres, with perhaps Cheyne-Stokes respiration and glycosuria.

The **later results** of a cerebral laceration vary much. The patient may recover perfectly after a more or less prolonged period of unconsciousness, but not unfrequently some loss of power persists, which will seriously impair the patient's subsequent usefulness.

The febrile phenomena already mentioned as characteristic of the first few days of convalescence after an attack of concussion may pass into a condition of subacute or chronic localized inflammation of the injured area, as indicated by pain and headache. In such cases the inflammatory effusion may be so abundant as to determine the onset of unconsciousness in four or five days. Occasionally an abscess forms deeply in the white substance, and this will be indicated by the usual phenomena of such a condition, coming on ten or fourteen days after the injury.

The formation of cicatrices between the brain and membranes may determine the development of traumatic epilepsy or insanity at a later period (p. 780).

The **Treatment** of these cases is always an exceedingly anxious matter for the surgeon. In the majority of instances it is merely symptomatic, following the usual course adopted in concussion, compression, cerebral irritation, etc., as indicated elsewhere. Depressed bone, if present, will, of course, be dealt with by operation. Early convulsions and paralysis are carefully watched to see if any indication as to the site of the bleeding can be obtained, since it is possible that trephining over the injured spot and removing blood-clots or securing bleeding-points might be advisable; but the clinical records as to such treatment are not very encouraging. Late convulsions and paralysis due to inflammation are best treated by shaving the head and applying an ice-cap, and by lumbar puncture. If the pulse is full and hard, and the patient otherwise young and healthy, general venesection may be adopted; the bowels must be moved by a smart purgative, such as croton oil, whilst bromide in full doses may be administered. If the convulsions continue in spite of such treatment, and become more severe and extensive, the patient will almost certainly die of coma; trephining over the injured area is then distinctly indicated, the surgeon hoping to find and remove some clot, or, at any rate, to relieve tension by decompression.

II. **Penetrating Wounds of the Brain** result from blows or falls, as in compound depressed fractures; or from the entrance of foreign bodies, such as bullets; or from stabs or punctures, which most commonly occur in the weaker parts of the cranium—*e.g.*, the temple or upper wall of the orbit; or from sabre-cuts or axe-wounds, in which an oblique or almost valvular incision is made through the scalp and cranium, laying bare and wounding the brain and its membranes.

In these cases the general disturbance is often slight, compared with the extent of the local injury, so that, although brain substance may protrude from the wound, there is sometimes but little concussion. Any of the conditions due to hæmorrhage detailed below may follow, but they may be slight, since the blood can escape from the wound. The inflammatory phenomena due to ***infection*** of the wound may be localized or diffuse. In the latter instance general meningo-encephalitis manifests itself in the course of two or three days, and is rapidly fatal; in the former case adhesions prevent the extension of the trouble beyond the neighbourhood of the wound. Hernia cerebri is very likely to follow, and possibly a deep cerebral abscess may complicate matters at a later date. In cases that have been successfully rendered *aseptic*, the course is similar to that run by a non-penetrating wound, except that, if anything, the immediate prognosis is better, since the opening in the skull diminishes the likelihood of compression from simple or spreading œdema. Where the lesion has involved the motor area, permanent monoplegia may persist, and traumatic epilepsy is always liable to result owing to the formation of cortical adhesions

Treatment.—In all cases of punctured or compound depressed fracture, a thorough exploration of the wound should be made, and all depressed or injured bone removed. Foreign bodies should be taken away, if found close to the wound; but it is doubtful whether a bullet should be sought for, if it has penetrated deeply into the brain, or if it has traversed the brain and fractured the bone on the other side. Probably an aseptic incision, with removal of the splintered fragments and a limited search for the bullet, is the best treatment to adopt, and, even if unsuccessful, will do but little harm, if the patient's general state warrants an operation. Protruding brain tissue is gently removed, and the whole wound thoroughly purified with carbolic lotion; even the 1 in 20 solution may be used without fear. The dura mater should, if possible, be drawn together by one or two sutures, and a small drain-tube or a gauze wick inserted within it. It is often advisable to introduce a portion of sterilized gold or silver foil between the cortex and the dura, so as to prevent the formation of adhesions. The scalp-wound is closed, except at the drain opening; the gauze or tube should be removed, if all is going well, in about two days' time. If the temperature rises as a result of infection, the wound must be reopened, and every effort made to relieve tension, and thus localize the mischief. Should diffusion occur, as indicated by an increasing severity of the symptoms, the patient must be treated in accordance with the general principles laid down for dealing with acute meningitis.

In this description of lacerations of the brain the fact that symptoms may arise from inflammatory conditions affecting the bones (p. 728) has been purposely omitted. In actual practice the course of events is often considerably modified by such complications.

Injuries to the Intracranial Bloodvessels.

1. **Wounds of the Venous Sinuses** are by no means uncommon, being torn across in fractures, or punctured either by some sharp instrument, or by spicules of bone. The superior longitudinal, petrosal, lateral, and cavernous sinuses are those most frequently involved, especially the first, because it is more intimately connected with the bones than any of the others. Not unfrequently a depressed fragment of bone is driven into a sinus, and no bleeding occurs until the fragment is displaced with a view to elevating it, when a serious gush of dark venous blood will follow. When there is no external wound, and the outer wall of the sinus has been torn, the hæmorrhage may strip up the dura mater and compress the brain, producing effects resembling those due to a wound of a meningeal artery; but generally the bleeding is not great, since comparatively little pressure suffices to arrest it by determining thrombosis. If, however, the inner wall of the sinus is torn across, the blood finds its way between the meninges, and gives rise to the symptoms of diffuse intrameningeal hæmorrhage. When an external wound exists, there is the usual evidence of venous bleeding, but it is readily

checked and rarely fatal. Infective thrombosis and pyæmia are the chief dangers, but entrance of air has also led to a fatal issue in a few cases. **Treatment,** when practicable, consists in plugging the sinus with aseptic gauze, and applying an antiseptic compress, possibly removing fragments of bone in order to expose it. Where the outer wall alone has been torn, it may be possible to suture it without interfering with its continuity. For symptoms and treatment of infective thrombosis, see p. 768.

2. **Wounds of the Middle Meningeal Artery.**—This vessel enters the skull at the foramen spinosum, and subsequently divides into two branches which ramify between the skull and the dura mater. The anterior branch is most frequently torn as it crosses the antero-inferior angle of the parietal bone, as the result of any type of fracture in that locality. The artery is, however, sometimes ruptured by a blow on the side of the head, sufficiently severe to detach the dura mater, but without causing any injury to the bone; this membrane always carries the vessel with it, and if it emerges from a bony canal just at that spot, as so often happens, the artery is torn across by the projecting inner lip of the canal. Whether or not the dura is primarily detached, the blood soon collects between it and the bone, pressing the brain inwards, and burrowing down towards the base of the skull (Fig. 366). This is due mainly to the force-pump-like action of the arterial pressure, for when fluid is driven into a closed cavity, the power of the jet is multiplied by the area occupied. The clot rarely measures more than 4 inches in diameter. The posterior division is only wounded in about 5 to 10 per cent. of the cases.

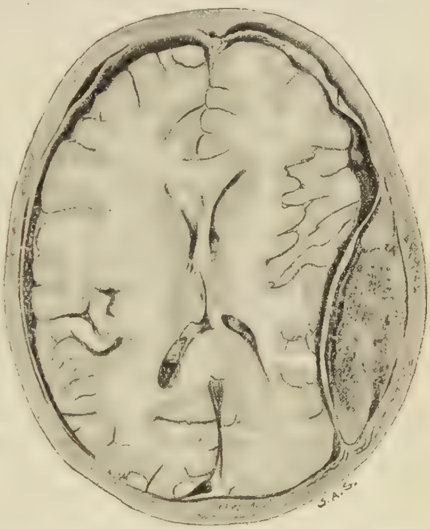

FIG. 366. — MENINGEAL HÆMORRHAGE (FROM SPECIMEN IN COLLEGE OF SURGEONS' MUSEUM.)

The **Symptoms** are, unfortunately, often obscured by some co-existent cerebral lesion or complication; but in a typical case three stages should be present, viz.: (*a*) A primary concussion, as the result of the blow; (*b*) a temporary return to consciousness; and (*c*) the gradual supervention of coma within twenty-four hours, and that usually without any considerable rise of temperature, though it may be associated with severe pain in the head and vomiting. The interval of consciousness varies widely, but it is not often longer than an hour or two, whilst in many cases it is scarcely recognisable. On the other hand, cases are known where symptoms were delayed for days or even weeks after an injury. As accessory signs, the following may be mentioned: (1) Since the blood-clot is situated close to the motor area of the cortex, and especially over the centres of the head and arm, twitching of these parts, followed perhaps by paralysis, may be a well-marked feature, and usually supervenes before the onset of coma; (2) when the clot extends to the base of the skull, it presses on the cavernous sinus, and may induce passive congestion of the eyeball, paresis of some of the ocular muscles, and proptosis, with possibly a dilated pupil and high temperature; and (3) when a fissure exists in the bone, blood may filter through into the temporal fossa, and cause a marked fulness in that region. The **Prognosis** is extremely unfavourable, Von Bergmann stating that out of ninety-nine cases only sixteen recovered.

The **Diagnosis** of extra-dural as distinct from intra-dural hæmorrhage is by no means simple. The latter is usually more rapid in its onset, and if involving the motor area may be associated with definite cortical phenomena; it is likely to be associated with blood-staining of the cerebro-spinal fluid. Unfortunately, the two conditions not unfrequently co-exist, and even if an extra-dural hæmorrhage is diagnosed it is difficult to be certain whether it is arterial or venous in origin.

The **Treatment** consists in trephining in order to remove the blood-clot and secure the artery, if still bleeding. The spot selected for dealing with the anterior division of the artery is 1½ inches behind the external angular process of the frontal bone, and 1½ inches above the zygoma (Fig. 370, F), and this point may be marked on the bone with a bradawl through the scalp before commencing the operation. The scalp is shaved and thoroughly purified, and a flap turned down, including everything as far as the pericranium (Fig. 105, A). A crucial incision is then made over the selected spot, and the pericranium reflected sufficiently to allow a 1-inch trephine to be applied. On removing the disc of bone, a mass of blood-clot presents, which should be broken up with the finger and washed or scraped away. If the artery is seen bleeding on the dura mater, it may be possible to pick it up, and tie or twist it, or a fine curved needle threaded with catgut may be passed under it, and thus a ligature applied. If, however, the blood comes from a canal in the bone, the outer table must be clipped away sufficiently to enable the canal to be seen and plugged by a small piece of aseptic wax, sponge, or gauze, which may be left without danger. The flap is then replaced, and stitched down, a drain-tube being inserted for a time.

The posterior branch of the artery can be reached by trephining immediately below the parietal eminence at the same level as for the anterior branch—*i.e.*, 1½ inches above Reid's base-line; or, again, it can be exposed nearer its origin at a spot 1¾ inches behind the external angular process of the frontal bone, and ¼ inch above the upper margin of the zygoma (Fig. 370, G).

3. **Wounds of the Internal Carotid Artery,** in its intracranial portion, are rare, but if complete are necessarily fatal. They usually result from penetrating wounds of the orbit, or from a gunshot wound, or the vessel may be torn by a splinter of bone in a fracture of the base of the skull. Mere fissures through the carotid canal do little harm, since there is plenty of room within it around the artery. Occasionally, however, the artery is slightly torn, and an aneurismal varix develops between it and the cavernous sinus. **Treatment.**—The injury is fatal in the majority of cases before help can be obtained; if not, compression of the carotid trunk or ligature of the internal carotid in the neck is the only hope. See also on orbital aneurism (p. 323).

4. **Intrameningeal Hæmorrhage** arises from wounds of the cerebral cortex or membranes in cases of fractured skull, or from concussion without fracture. The blood may be derived from the veins and capillaries so abundantly present in the pia mater, or from lesions of the inner wall of venous sinuses, or even from the middle meningeal artery, if the dura mater is also opened. It may be widely diffused over the surface of the hemispheres, or be more localized. It is often but slowly absorbed, and may become encapsuled, constituting what is known as an *arachnoid cyst—i.e.*, a closed cavity containing serum, the walls of which are formed of fibrous tissue stained brown with hæmatin.

The **Symptoms** are those of concussion or compression, and need not be discussed further.

The **Treatment** is symptomatic, the patient being kept absolutely quiet, and all excitement and noise which might induce cerebral congestion excluded. Should there be any focal symptoms indicating the position of greatest pressure, or should there be some concurrent lesion of the skull, the trephine may be applied at this spot. It must not be forgotten, however, that the chief hæmorrhage often occurs, not at the point to which the injury was directed, but at an exactly opposite spot on the other side of the cranium, and hence considerable uncertainty may arise both as to the advisability of an operation and as to its site. Should the right locality have been exposed, the dura mater will probably bulge into the wound, after the circle of bone has been removed; it is blackish-blue in colour, owing to the clot lying beneath it, and the cerebral pulsations will not be detected. It is carefully incised, and the blood-clot removed; any bleeding-points should be tied or compressed, and it may be necessary to insert a small wick of aseptic gauze for a day or two, in order to drain off serum and blood.

5. **Cerebral Hæmorrhage** occurs more frequently from idiopathic causes than from trauma, except in the case of severe lacerations. In the more aggravated forms, death is almost certain to follow in a short time from coma.

Intracranial Inflammation.

Inflammation of the cranial contents is almost always bacterial in origin, and may follow a great variety of lesions, *e.g.:* (1) Injuries of all types, but especially compound or punctured fractures. (2) Middle-ear disease is perhaps the most frequent origin of these affections, the infection reaching the brain through an opening in the tegmen tympani, or spreading from the mastoid process along the sigmoid groove in which lies the lateral sinus. (3) It may extend inwards from scalp, face, nose, or neck by way of the emissary veins, or even along the sheaths of nerves. (4) It may accompany simple contusion of the cranial bones (p. 730), as a result of an auto-infective inflammation in these structures. (5) It may develop as a complication of pyæmia, septicæmia, pneumonia, scarlet fever small-pox, and other general infective diseases.

The causative bacteria are generally of the usual pyogenic type, viz., staphylococci and streptococci, when the inflammation is due to traumatism; but the pneumococcus is present, as a rule, when the mischief extends from the middle ear or accessory nasal sinuses. In the so-called idiopathic form of diffuse meningitis the *Diplococcus intracellularis* of Weichselbaum is generally the causative organism.

It must be remembered that in actual practice the different forms of inflammation described below run into one another, and that the resulting symptoms are often a complex mixture of several types. For descriptive purposes the following groups may be differentiated:

(i.) **Subcranial Inflammation** manifests itself either as a simple thickening of the dura (*pachymeningitis*), or as an effusion of pus between the dura and the bone (*subcranial abscess*).

Simple Pachymeningitis results either from a slight simple depressed fracture, or from a contusion with or without a fissured fracture, or from the gradual spread of a mild infective inflammation from the overlying bone. The process is really protective in character, the dura becoming thickened. It may extend to the under surface of the dura, and lead to a localized lepto-meningitis, characterized by adhesions between the cortex and the dura. If the process extends no further, the clinical manifestations are slight, consisting merely of pain and localized headache. For treatment, see chronic meningitis (p. 768).

Subcranial (or **Extradural**) **Abscess** results from either a compound depressed or a punctured fracture, in which the dura mater is only separated from the bone and not lacerated, especially when the external wound is small and efficient drainage is not obtained. It sometimes occurs, however, in consequence of a simple contusion or fracture of the skull, leading to a detachment of the membranes and a collection primarily of blood and later of inflammatory fluids in the cavity thus produced. Microbic invasion is here due to auto-infection, or to the passage of organisms through the bone (Fig. 367). Any form of osteo-myelitis of the cranial bones may determine its onset, but apart from injury, its most common cause is, without doubt, extension of inflammation from the middle ear.

A perforation of the tegmen tympani (Fig. 369, B) allows of the invasion of the cranial cavity, and an abscess forms above the attic, which perhaps discharges through the ear; in other cases the suppuration extends along the groove for the lateral sinus. In the former instance, a localized subdural abscess may subsequently develop, limited by meningeal adhesions, and the intervening dura mater may slough; in the latter, thrombosis of the lateral sinus may follow.

The **Symptoms** produced are (1) those generally characteristic of suppuration, viz., a high temperature, with perhaps rigors. (2) The signs of intracranial pressure in the form of fixed headaches followed by coma are also present, if the abscess is large, or if it affects the cerebral membranes sufficiently to cause a serous meningeal effusion. (3) If there is no open wound, an œdematous swelling of the scalp, known as *Pott's puffy tumour*, may develop over the site of the abscess (Fig. 367). When there is a compound fracture of the skull, the margins of the wound look unhealthy, and at its base may be seen bare bone, yellow and dry, from which the pericranium has separated, with perhaps pus oozing out between the fragments. If the pus burrows towards the base of the skull, optic neuritis may develop. (4) Focal symptoms of spasm or paralysis may complicate the case if the dura over the motor area is involved. The **Treatment** of such a condition consists in evacuating the abscess cavity through a sufficient opening made by trephining, or by removing loose or diseased portions of bone, and providing for drainage. Sometimes more than one opening is required for this purpose.

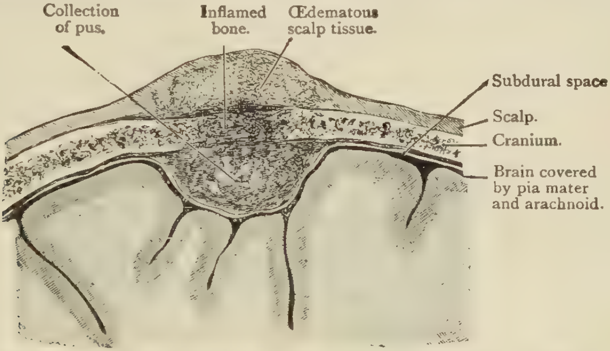

FIG. 367.—SUBCRANIAL SUPPURATION, INVOLVING OVERLYING BONE AND CAUSING AN ŒDEMATOUS CONDITION OF THE SCALP—POTT'S PUFFY SWELLING (SEMI-DIAGRAMMATIC). (FROM TREVES' 'SYSTEM OF SURGERY.')

When the affection follows middle-ear mischief, the mastoid antrum is usually opened up, as also the attic, and a sufficient amount of bone gouged or cut away to give effective drainage.

(ii.) **Acute Diffuse Meningitis (lepto-meningitis)** is always infective in nature. The symptoms vary considerably in their intensity according to the site and method of inoculation and the activity of the organisms, but the whole pio-arachnal space is quickly involved. The superficial part of the brain is also invaded in the inflammation as well as the meninges, and the term 'meningo-encephalitis' would perhaps be the better appellation.

The **Symptoms** appear about forty-eight hours after an injury, although sometimes infection may be delayed beyond this period. In the early stages the patient complains of severe, constant, and increasing headache, associated with heat of head, a forcible pulsation of the carotids, a quick pulse, and general irritability of the brain, as indicated by vomiting, intolerance of light and sound, delirium, and perhaps convulsive twitchings of the muscles, not only of the head and back, but also of the extremities. The vomiting is of the usual cerebral type—*i.e.*, it occurs apart from nausea, and has no relation to the ingestion of food. High fever is generally present, and possibly a rigor may occur at the onset. As the disease progresses, the patient gradually becomes comatose, the pulse slow and full, the respirations laboured, and death usually ensues in three or four days.

According to the site of infection, the inflammatory phenomena may manifest themselves more acutely over one part than another, and for descriptive purposes two chief varieties have been distinguished, viz., meningitis of the convexity and meningitis of the base. The general symptoms are alike in both forms, but when the convexity is involved, convulsions are a more prominent feature in the case, and may at first be limited to localized groups of muscles; whilst in basal meningitis the temperature tends to run higher, the head and neck are more retracted, optic neuritis is more frequent, and some form of squint is not uncommonly observed.

On *post-mortem* examination the skull-cap is separated from the meninges with some difficulty; the dura mater is thick and congested, and the subjacent veins are manifestly distended; the cerebro-spinal fluid is increased in amount, and turbid from admixture with lymph or pus; the arachnoid is thick and opaque; the surface of the convolutions is flattened and œdematous, and lymph occupies all the sulci, matting them together; the cortical gray matter is usually red and congested; the underlying white substance of the centrum ovale is injected, numerous puncta cruenta being evident; the ventricles are distended with cerebro-spinal fluid, and the choroid plexuses are engorged with blood.

The **Treatment** consists in shaving the head and applying cold by means of an icebag or Leiter's tubes, care being taken that the application is continuous, and not intermittent. In the robust general venesection is useful, but in weaker individuals cupping or leeching may replace it. The bowels are freely opened and a bland diet ordered. The patient should be kept absolutely quiet in a darkened room, and every source of irritation and excitement removed.

Even if recovery ensues, it is somewhat delayed, and similar precautions as to quiet, etc., must be maintained for some time. In the later stages, blistering of the scalp or neck, and the administration of mercury, are advisable.

If the condition is due to a localized infective lesion, this must, of course, be dealt with by suitable means—*e.g.*, the middle ear must be opened up and diseased bone removed, depressed fractures must be operated on, and localized drainage effected, etc. Apart from this, attempts have been frequently made to relieve the symptoms and determine a cure by means of operative measures, directed towards reducing the intracranial tension; the subarachnoid space has been opened below the tentorium, whilst others have successfully employed lumbar puncture, repeating it frequently (p. 748). When one considers the intricate character of the space to be drained, the fact that it is sure to be subdivided into separate cavities by deposits of lymph, and especially when it is remembered that the brain substance is itself swollen, and that the important fourth ventricle has only a small communication with the subarachnoid space—all these considerations suggest that it is unlikely that much success will follow such treatment.

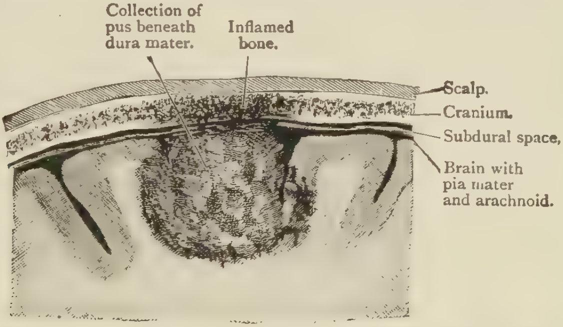
Collection of pus beneath dura mater.
Inflamed bone.
Scalp.
Cranium.
Subdural space,
Brain with pia mater and arachnoid.

FIG. 368.—SUPERFICIAL ABSCESS OF BRAIN, SPREADING FROM SUBDURAL SPACE (SEMI-DIAGRAMMATIC). (FROM TREVES' 'SYSTEM OF SURGERY.')

Acute Meningo-encephalitis is sometimes *limited* in character. It can only occur in the absence of tension, diffusion along the meninges being prevented by the formation of adhesions. It usually results from a localized inflammation of bone (Fig. 368), due to a contusion, a penetrating wound, or possibly to middle-ear mischief. The process ends in the formation of adhesions between the brain and its membranes, preceded or not by suppuration. Of course, where pus forms, a cure can only be established by operation.

(iii.) A **Subacute** form of meningitis is occasionally met with, coming on at a somewhat later date. The patient may have apparently recovered from his injury, with the exception of a fixed pain in the head. The onset of the symptoms is often due to some indiscretion, and may be gradual or sudden. In all probability this affection is also microbic in origin, and the delay in its appearance depends either on the small number of bacteria present, or on their being in a low state of virulence; or possibly they have been latent for a time, and are aroused into activity by secondary causes; or, again, they may have gradually worked their way inwards along lymphatics or vessels from the periphery to the meninges. The symptoms are similar in character to those of acute meningitis, though somewhat less severe; but a fatal result is very apt to follow. In the *treatment* of this form, no active antiphlogistic measures should be adopted, since the patient's condition is somewhat asthenic. Absolute rest and quiet are essential; counter-irritation should be applied to the scalp and neck, and possibly mercury administered, or some absorbent organic salt of iodine.

(iv.) **Chronic Lepto-meningitis** arises from very similar causes to the pachymeningitis already described (p. 764), but in addition may be associated with deep lesions, and may serve to limit the spread of infection; it is usually of a protective character. Syphilitic patients are perhaps more liable to its development than others. It is evidenced by infiltration and thickening of the membranes, which are usually adherent to one another and to the cerebral cortex. It gives rise to a localized headache, which is constant, and increased on excitement or the injudicious use of stimulants, whilst tenderness is often noted on deep pressure, and traumatic epilepsy may ensue. The *treatment* consists in attention to the general health, free action of the bowels, abstinence from excitement or stimulants, the local application of counter-irritants, and the administration of mercury or iodolysin (p. 632). For the question of operating for traumatic epilepsy, see p. 780.

(v.) **Tuberculous Meningitis** is a condition usually seen in children, due to an invasion of the meninges with tubercle. The pial vessels are chiefly affected, and the base of the brain is mainly involved. Inflammatory adhesions follow, and the free circulation of the cerebro-spinal fluid is checked by the blocking of the foramina of Magendie and Luschka, so that the ventricles are often distended. For symptoms and clinical history, medical text-books must be consulted.

Many attempts have been made to deal with this affection by surgical means, especially by trephining through the occipital region and draining away the cerebro-spinal fluid, so as to relieve pressure on the fourth ventricle, or by lumbar puncture. One or two cases have recovered *post hoc*, but the prospects of success are poor.

(vi.) **Infective Thrombosis of the Sinuses,** though occasionally seen after injuries, is more commonly associated with suppurative diseases of the bone apart from trauma, and one variety, viz., that affecting the lateral sinus, is almost exclusively caused by disease of the middle ear. It is also induced by extension from scalp injuries as a complication of subaponeurotic cellulitis, or may spread inwards from erysipelatous or pyogenic lesions of the face, or suppurative conditions of the nose. Putting aside the results of chronic otorrhœa, the cavernous sinus is much more frequently involved than any other, and the affection is often secondary to suppuration in the sphenoidal sinus.

Pathologically, the same manifestations are observed as in any case of infective phlebitis. The sinus becomes impervious owing to thrombosis, and the clot becomes disintegrated and gives rise to multiple emboli, whilst various inflammatory conditions of the surrounding tissues necessarily result—*e.g.*, necrosis or caries of bones; subcranial abscess; meningitis, simple and localized, or infective and diffuse; or even cerebral or cerebellar abscess.

The *symptoms* are mainly of a pyæmic nature. The temperature is high, but with remissions, and often with repeated rigors; fixed headache and early and continuous vomiting are also marked features of the case. With these may be associated evidences of meningeal mischief, or of pulmonary trouble in the shape of dyspnœa, but sometimes diarrhœa and septicæmic manifestations may be the more prominent.

If the cavernous sinus is involved, marked exophthalmos, with congestion of the orbit, and even of the eyelids and face, may result, and ptosis or squint may also be set up by implication of the nerves which lie in the walls of the sinus.

If the superior longitudinal sinus is affected, there may be turgescence of the veins of the scalp and forehead, together with tenderness along the line of the sinus and epistaxis, whilst convulsions may be induced by irritation of the neighbouring motor area.

For local results and treatment of thrombosis of the lateral sinus, see p. 882.

Treatment, except for the lateral sinus, is but rarely possible, and hence the importance of preventing this disease by a most careful attention to asepsis in the surgery of the face and of the nasal cavity. For the lateral sinus much can be done, but for the other sinuses all that is feasible is attention to general measures.

Abscess of the Brain.

Causes.—Pyogenic infection is, of course, the ultimate cause of all cerebral suppuration, but the manner in which the organisms find their way to the brain varies considerably.

(i.) It may be due to *traumatism*, either in the early or late stages of head injuries. In the *early*, it is usually superficial, and connected with some infective lesion of the scalp, cranium, or membranes, with or without a penetrating wound (Fig. 368). In the *later* stages the pus forms deeply in the white substance. It may be due to a penetrating wound, whether a foreign body is present or not, the microbes finding their way into the interior of the brain either through the track of the missile, or along bloodvessels or lymphatics. Sometimes it occurs apart from penetration, and then one can only suppose that it is due to auto-infection of a contused or lacerated area. Chronic abscess of this type is most frequently seen on the same side of the brain as the lesion, and the parietal and frontal lobes are most often affected; occasionally, however, it may occur on the opposite side in the same way as a contusion.

(ii.) It arises by extension of an infective lesion from without, the organisms reaching the brain by direct continuity of tissue, or by way of the bloodvessels or lymphatics. The commonest cause of all abscesses in the brain is *chronic otorrhœa* (Fig. 369), and the cerebellum is nearly as frequently involved as the cerebrum. In the former the abscess is usually in the anterior portion of the lateral lobe (D), close to the back of the petrous bone, whilst in the latter the posterior portion of the temporo-sphenoidal lobe is most frequently affected (C). The inflammation may spread directly from the tympanic cavity or inner aspect of the mastoid process through the bone to the membranes, which become adherent to the brain, and then into the cerebral substance. Occasionally a subcranial abscess is first developed (Fig. 369, B), and the cerebral affection follows; sometimes a direct opening has been found through the tegmen tympani into an abscess cavity, and the abscess has even discharged itself and been drained in this direction. More commonly a layer of brain tissue intervenes between the membranes and the pus, and then infection must have been carried along vessels and lymphatic sheaths running between the meninges and the brain.

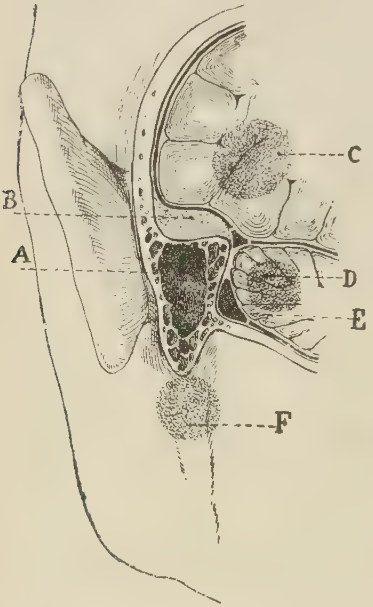

Fig. 369.—Diagram to represent the Course of Inflammatory Trouble from Suppurative Disease of the Middle Ear.

A, dilated and infected mastoid antrum; B, subcranial (extradural) abscess from infection through the roof of middle ear or mastoid; C, abscess in temporo-sphenoidal lobe; D, cerebellar abscess; E, lateral sinus; F, Bezold's abscess through perforation of tip of mastoid process.

Abscesses of a similar type occur in connection with suppuration in the frontal sinus, the abscess being usually acute and secondary to a frontal osteo-myelitis, and occupying the anterior portion of the frontal lobe; it may also follow purulent infection of the sphenoidal and ethmoidal sinuses, or thrombosis of the cavernous sinus.

(iii.) The infective material may be brought to the brain by the blood in pyæmia, or after some of the exanthemata, such as scarlatina, typhoid, etc. Abscess of the occipital lobe is almost always of pyæmic origin.

(iv.) A chronic abscess of tuberculous origin may also occur.

A cerebral abscess is usually single; occasionally more than one is present, *e.g.*, a cerebral and cerebellar may co-exist in connection with middle-ear mischief. The course taken by the case is generally chronic, and then the pus is encapsuled; in acute cases there is usually no limiting membrane. A chronic case not uncommonly terminates in an outbreak of acute symptoms, due either to the abscess bursting into one of the lateral ventricles, or to the supervention of spreading œdema.

The **Symptoms** vary somewhat with the method of onset and the characters of the abscess. If traumatic and due to infection from without, the case runs an acute course, associated with intense pain in the head, recurrent rigors, and rapid development of coma. Diffuse meningitis is often present, and the two conditions can scarcely be distinguished. In not a few of the cases of chronic abscess, all that the patient complains of is headache, until suddenly the temperature rises with a bound; he becomes unconscious and dies within a day or two. Such a course of events is probably due to the bursting of the abscess into the lateral ventricle or meningeal cavity, or to the onset of an acute spreading œdema.

When the symptoms are more characteristic, Sir W. Macewen describes them in three well-marked stages. (i.) In the *Initiatory Stage*, which lasts from twelve hours to two or three days, the patient is suddenly seized with severe pain in the region of the ear, radiating perhaps throughout the head, and accompanied by a rigor of some severity. The temperature and pulse are both raised, and vomiting of a cerebral type is present; the tongue is foul, whilst anorexia and constipation are well marked. During this period the otorrhœa diminishes, or ceases entirely.

(ii.) In the *Fully-developed Stage* the patient lies quietly in bed in a dull, apathetic condition, able to answer questions but slowly, and with his brain evidently in a torpid state. The headache has to a great extent ceased, but tenderness over the temporo-mastoid region still remains. The temperature gradually falls and becomes subnormal; the pulse is slow and full; and respiration is usually slow. The vomiting and constipation continue, and the patient's mouth and breath become very offensive. Loss of muscular power scarcely amounting to paralysis occurs in many cases where the motor track is involved, and the order in which this paresis appears is of localizing value. Thus, if a temporo-sphenoidal abscess is not far from the cortex, the face is first affected, then the arm, and finally the leg; but if the abscess is deeper and presses on the motor fibres in the internal capsule, the order in which these parts are involved is reversed. Motor aphasia is sometimes well marked when the abscess is on the left side. If the abscess is placed posteriorly, it may press on the cerebellum through the tentorium, and cause symptoms of a cerebellar type. Optic neuritis (p. 776) is a somewhat unreliable sign, but if present is more marked on the affected side, whilst the corresponding pupil is dilated and fixed.

(iii.) The *Terminal Stage* is marked by a gradually increasing unconsciousness and death; or the abscess may burst into the lateral ventricle, causing sudden coma, a rapid rise of temperature and pulse, irregular respirations (often of a Cheyne-Stokes type), and death; or it may burst into the subarachnoid space, and then death is preceded by symptoms of diffuse lepto-meningitis.

The signs connected with a small **Cerebellar Abscess** (Fig. 369, D) are often very indefinite and vague, but if the abscess increases in size, the symptoms may become very characteristic. The patient complains of giddiness, and staggers when attempting to walk, falling towards the opposite side. The head and neck are retracted; respiration is irregular and feeble; the pulse is often slow and weak; paralysis may be noted on one or both sides of the body, and may only affect the upper extremity; of course, vomiting, optic neuritis, and a low temperature are present.

Diagnosis.—From *meningitis*, a cerebral abscess is usually recognised by the fact that in the former condition irritative phenomena, such as acute and active delirium, contraction of the pupil, photophobia, rigidity and spasm of muscles, especially in the back of the neck, and severe pain, are more evident and are produced earlier. The temperature is usually high, and mental dulness comes on within three or four days of an injury, whereas an abscess rarely forms before the end of the first week. *Extradural abscess* (subcranial) is associated with a high temperature, earlier onset after an injury in traumatic cases, and more rapid compression symptoms; optic neuritis is unusual, and the vomiting is less troublesome. There is also likely to be some localized œdema or tenderness on deep pressure. In *thrombosis of the lateral sinus* the temperature is high and oscillating, optic neuritis may be absent, and there may be the characteristic tenderness in the neck along the course of the internal jugular; in abscess symptoms of compression are associated with a low temperature and marked optic neuritis. It must not be forgotten that the two conditions may co-exist. It is often impossible to diagnose between a chronic abscess and a *tumour of the brain*; the symptoms in the latter usually come on more slowly than in the former, but the progress is steady and unrelenting; the temperature remains near the normal, and there is less gastric disturbance. The history of the case may throw some light upon its nature, since in cases of cerebral abscess there is generally some causative focus of infection. Tumour is more common in the frontal and parietal regions, abscess in the temporo-sphenoidal lobe. Optic neuritis is more marked and more common in tumour than in abscess.

Treatment necessarily follows the usual rule, viz., to give an exit to the pus as soon as possible; no delay is permissible when once the diagnosis is certain. The patient is prepared in the same way as for operation on a cerebral tumour (p. 777). A flap of scalp tissue is raised, and in such a manner as will most effectually serve for subsequent drainage purposes. The trephine is applied according to the rules given below, or in accordance with the special indications given by the symptoms of the case. Sir W. Macewen recommends that, when the circle of bone has been removed, the exposed surface and cut edge should be well rubbed over with powdered iodoform and boric acid, so as to guard them from infection. The dura mater, which bulges into the wound and does not pulsate, is then carefully incised. A mere slit often suffices, and this may open the abscess; but more usually the brain substance protrudes. It is carefully explored with a pair of sinus forceps, which is passed directly into it in various directions, or with a fine trocar and cannula. In a temporo-sphenoidal abscess the most likely direction to explore is downwards and inwards towards the tegmen tympani. Pus, when discovered, is allowed to escape by opening the blades of the sinus forceps. Sloughs are not uncommonly present in the cavity, and are removed by the gentle introduction of a curette, whilst it is wise to wash out the interior by gentle irrigation with sterilized salt solution. A drainage-tube is advisably inserted, and may be kept in position by stitching it to the margins of the incision in the dura, which is closed except for the passage of the tube. Sometimes it is wiser not to close the flaps around the tube, but to pack gauze round it, thereby determining the formation of adhesions, which will serve to shut off and guard from infection the meningeal cavity. The scalp flap is replaced in position, the tube being brought out through its centre, if need be. The tube is retained in position for two or three days, and is then removed. Symptoms of re-accumulation or of extension of the mischief to the meninges will, of course, necessitate a re-opening of the wound, and the institution of free and effective drainage. Occasionally a hernia cerebri develops as the result of opening a cerebral abscess.

For an abscess in the temporo-sphenoidal lobe, the centre-pin of the trephine may be placed 1¼ inches above Reid's base-line, and directly above the external auditory meatus; but a better situation is a spot ¾ inch above the posterior root of the zygoma, and directly above the posterior border of the osseous meatus (Macewen; Fig. 370, D). For an abscess in the cerebellum the point selected is 1½ inches behind the centre of the external auditory meatus, and ¼ inch below the base-line (Fig. 370, E). In the latter case the soft parts, including the muscles and periosteum, should be stripped off the occipital bone, and turned downwards, and it is usually inadvisable to apply a trephine, as the bone is very thin, and may be broken through with a gouge. It is often necessary to carry through the cerebellar operation rapidly, as the respirations sometimes stop under an anæsthetic, though the heart continues to beat forcibly; as soon as the dura is opened, the respirations recommence.

In middle-ear disease the diagnosis, both as to the presence of an abscess and its situation, is often doubtful. The antrum and attic are then opened and explored thoroughly, and according to whether the disease is more marked in the former or latter, the further steps

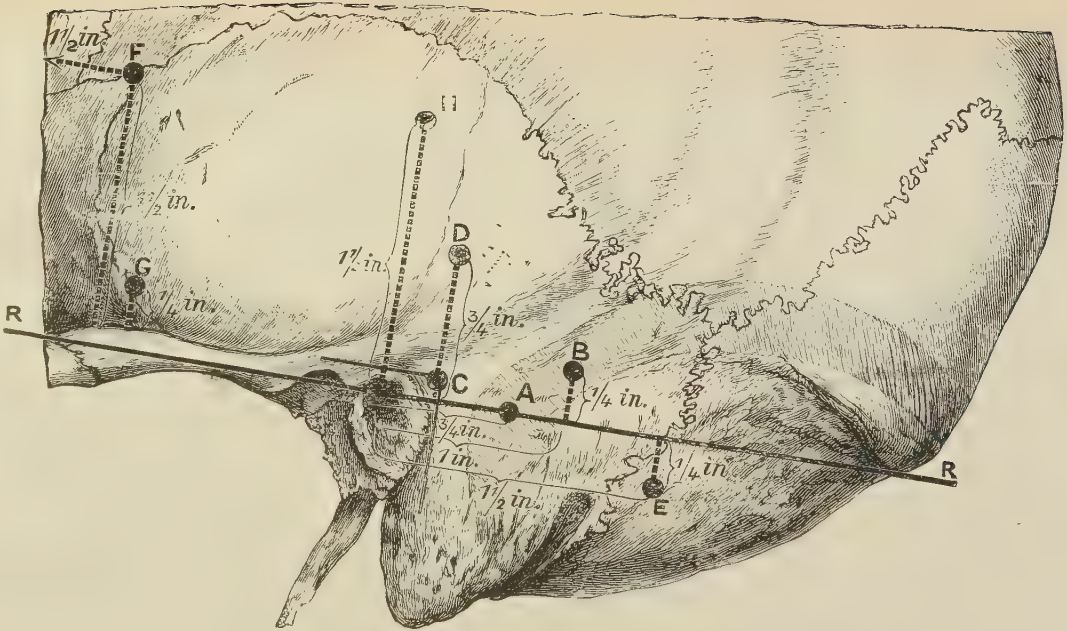

FIG. 370.—DIAGRAM OF ADULT SKULL (NATURAL SIZE) TO SHOW VARIOUS SPOTS FOR TREPHINING. (TREVES' 'SURGERY.')

The horizontal measurements are taken along Reid's base-line, R, R, which passes through the centre of the external auditory meatus; the vertical measurements are taken by drawing lines at right angles to the base-line. A, The sigmoid portion of the lateral sinus, a point ¾ inch along the base-line from the centre of the meatus; B, the transverse portion of the sinus, 1 inch behind the meatus, and ¼ inch above the base-line; C, the mastoid antrum, the point of meeting of two lines—one drawn along the upper wall of the meatus and parallel to the base-line, the other along the posterior wall of the meatus at right angles to Reid's line; D, for temporo-sphenoidal abscess, a line drawn ¾ inch upwards through the posterior border of the meatus at right angles to the base-line; E, for cerebellar abscess, 1½ inches behind the centre of the meatus, and ¼ inch below the base-line; F, for anterior branch of middle meningeal, 1½ inches behind external angular process of frontal bone, and 1½ inches above the zygoma; G, for posterior branch of middle meningeal, 1¾ inches behind external angular process, and ¼ inch above zygoma; H, for tapping lateral ventricle, 1½ inches above centre of external auditory meatus.

of the operation are directed towards the cerebellum or cerebrum. By carefully removing bone behind and above the antrum, the lateral sinus is exposed; and by working above or below it, the cerebrum or cerebellum can be examined, and, if need be, incised. A similar result can be obtained by applying a ¾-inch trephine to a spot 1 inch behind the meatus and ½ inch above the base-line (H. P. Dean). The lateral sinus lies in the lower portion of the opening, and the dura over the temporo-sphenoidal lobe in the upper; by enlarging the opening downwards by Hoffman's rongeur, the cerebellum can also be explored.

Cerebral Tumours.

The chief **Varieties** of new growth met with in the brain are as follows: (i.) *Glioma*, which consists of a small round-celled neoplasm with a very delicate intercellular substance, similar in character to the neuroglia (p. 214); it may occur in any part of the brain. It is always continuous with the surrounding cerebral tissue, and is scarcely ever encapsuled, so that to the naked eye it may be indistinguishable from brain substance, although rather harder, and hence its limits can seldom be accurately defined, or its removal completely effected. (ii.) *Sarcomata* and secondary carcinomata also occur, and are as unfavourable as the gliomata in their characters. (iii.) *Endotheliomata* are not uncommon tumours of the brain, growing usually from the membranes, and may attain considerable dimensions before causing symptoms. They press upon and excavate by pressure rather than infiltrate the brain, and their situation at the base of the skull and their size are often such as to preclude removal. In some cases they present the characteristic features of a psammoma (p. 228). (iv.) *Tuberculous foci* are met with either associated with or apart from any meningeal infiltration, varying in size considerably, and may be either firm and caseous, or with a diffluent centre. (v.) *Gummata* of the brain usually spring from the meninges, and are more irregular in shape than tuberculous masses. They are frequently multiple, and are seldom seen in children. (vi.) Occasionally *hydatid cysts* are found, as also other less common conditions.

Cerebral tumours are more often observed in males than in females, and the different forms occur at varying periods of life. Thus, glioma and sarcoma are most common at puberty or in middle life; tuberculous foci, in children; gummata, in the fourth or fifth decade; carcinomata, in middle or late life; and parasitic tumours in the second and third decades.

The *local effects* of a cerebral tumour may be to cause some amount of sclerosis of the surrounding brain substance, whilst, if superficial, the membranes may become adherent and the overlying bone thickened or eroded. Erosion and enlargement of the sella turcica can be shown by the X rays in cases of tumour of the pituitary body.

The **Symptoms** of a cerebral tumour in the early stages are comparatively seldom brought under the notice of the surgeon, but it is of the greatest importance that their significance should be recognised by the general practitioner, who ought in case of doubt at once to obtain the assistance of a skilled neurologist, as it is only through improved and earlier diagnosis that we may hope for better surgical results. When the later phenomena, which are almost entirely the result of intracranial tension, are observed, the time has often gone for successful interference. 'The old classical symptoms of tumour of the brain which are given in most of our text-books, although often found, are not always present, and if one waits for such symptoms we may wait too long' (*Macewen* at International Medical Congress, 1913).

The **early** symptoms consist in some localized modification of the cerebral function, probably combined with headache and perhaps vomiting. The character of the *localizing phenomena* varies, of course, with the part of the brain involved; thus, if the cortex of the motor area is affected, Jacksonian epilepsy is likely to result, in which a definite aura associated with a particular group of muscles precedes the fit, which develops in an orderly fashion; in the later stages the fits are replaced by paralysis, and a localized monoplegia may be an important sign of a cerebral tumour. A subcortical lesion produces localized paralysis without convulsions. Motor aphasia would suggest an affection of Broca's lobe; word-deafness, an implication of the hinder end of the temporal lobe; and hemianopsia of the occipital region. Interference with co-ordination, vertigo, and nystagmus point to mischief in the cerebellum, and the association of these phenomena with localized lesions of cranial nerves, especially of the seventh or eighth, points to the cerebello-pontine angle, a rather favourite site for tumours. The *headache* varies much in character, but is usually localized, occurs in paroxysmal attacks, and may be associated with local tenderness on deep pressure. It is increased by anything that causes passive congestion of the brain, such as coughing, and it is important to note that the sites of maximum pain and of the tumour often correspond. *Vomiting*, if present, is of the usual cerebral type—*i.e.*, it bears no relation to the ingestion of food, and is not preceded by nausea.

The **later** phenomena are purely those due to intracranial tension, which may aggravate or to some extent mask the localizing signs. Headache becomes more severe and persistent; vomiting and constipation are well marked; the patient becomes drowsy and apathetic, wasting rapidly, and the temperature is subnormal. *Optic neuritis* (choked disc or papillœdema) is generally present, and at first more marked on the side of the tumour. It is due to increased tension of cerebro-spinal fluid, which is thereby forced into the sheath of the optic nerve, and produces a condition of œdema, which extends to the lamina cribrosa, and causes serious interference with the return of blood and lymph from the retina. There is in reality no inflammatory element about it. In the earlier stages the margin of the disc becomes blurred and indistinct, and the retinal veins congested and tortuous; the neighbouring retina is œdematous, and the vessels are only seen at intervals; linear ecchymoses may also occur. The vision may at first be but little affected; but if the case persists, atrophy of the disc and blindness follow, even in cases of gummata which have progressed to cure by means of medicine, if that cure has not been attained quickly.

The **terminal** phenomena of a cerebral tumour are gradually increasing coma, and the supervention of symptoms similar to those of compression (p. 752), whilst the temperature may be subnormal or occasionally very high.

Treatment.—In every case, the possibility of the symptoms being due to gummatous disease must not be forgotten, and a test for the Wassermann reaction should always be undertaken; if positive, an intravenous injection of salvarsan may be given, or large and increasing doses of iodide of potassium (even up to 40 or 60 grains three or four times a day) should be administered, together with the inunction of mercury, before undertaking operative proceedings. Symptoms of gastric irritation must be prevented by giving some alkaline carbonate (especially the ammonium or soda salts), whilst the dose should be freely diluted with water.

Operation should be undertaken as early as possible, since, even if no tumour exists, the patient runs but little serious risk, whilst delay may prevent the removal of the growth.

The scalp should be entirely shaved a day or two previously, and very thoroughly purified. A quarter of a grain of morphia is injected about half an hour before the operation, with the idea both of reducing the vascularity of the brain and of dulling the patient's sensations, so that a smaller amount of anæsthetic is subsequently needed. Chloroform should be employed rather than ether, as it produces less congestion of the head. The surgeon marks the supposed site of the growth on the skull with a bradawl through the scalp. A large semicircular flap is then turned down, exposing a considerable area of the calvarium, so that, if a larger amount of bone than is expected needs to be removed, no fresh scalp incisions are required; moreover, the cicatrix will in this way be prevented from forming over the defect. One of the methods of opening the cranium already described (p. 746) is then employed; the further proceedings on the brain are carried out at once, or the intracranial portion of the procedure is delayed for a week or so. Under such circumstances the wound is re-opened, and the dura mater exposed.

The dura mater when laid bare under normal conditions is firm, but yields slightly to the finger, and allows the pulsation of the subjacent brain to be felt, if the latter is healthy and no undue pressure is present within; but if the intracranial tension is markedly increased, the dura mater bulges into the wound, feels firm and unresisting, and the cerebral pulsations are diminished or absent.

The dura mater is next incised crucially, or a flap turned down, care being taken to avoid, if possible, the main meningeal vessels;

the brain substance protrudes if the intracranial pressure is excessive. The region is gently explored by the finger, and any areas of abnormal hardness or softening noticed; failing this, a grooved needle is inserted in different directions, or a fine trocar and cannula. In introducing such instruments, care must be taken to make direct stabs, and never any lateral movements, which necessarily lead to laceration of the brain. The opening of the skull may be enlarged, if need be, either by the use of the bone rongeur or by additional small trephine holes. It is but rarely that a cerebral tumour is so placed that enucleation is possible; it is estimated that not more than 10 per cent. of all cerebral tumours are removeable. If, however, a cortical neoplasm is found, it is isolated from the surrounding brain substance by blunt instruments—*e.g.*, the handle of a scalpel or a flexible knife made of platinum, as suggested by Horsley—and the mass freely removed. Hæmorrhage is controlled by the application of fine ligatures, or by pressure with a hot sponge for a few minutes. The dura mater is then loosely stitched together, and a drainage-tube inserted, reaching to the bottom of the wound, and brought out at one angle of the incision in the skin, which may be closed by a continuous suture, or through the centre of the flap. After the operation, the patient must be kept absolutely quiet, with the head slightly raised. The drainage-tube is removed in twenty-four or forty-eight hours, and the scalp wound is usually healed in six or seven days.

When the tumour is inaccessible or irremoveable, or its situation doubtful, temporary benefit often results from *decompression*—an operation which consists in removing large areas of the cranium, and incising the dura mater, so as to allow a hernia cerebri to form The decompression is best undertaken over the supposed site of the tumour, but has sometimes been subtentorial, with a view to influencing beneficially the vital centres. A considerable measure of benefit follows such operations, as evidenced by an improved mental condition, loss of pain, retrogression of the optic neuritis, and the preservation of sight. Of course, sooner or later the continued growth of the tumour results in the patient's death.

In dealing with cerebellar tumours, or those in the neighbourhood, either by removal or decompression, Cushing's cross-bow incision may be employed. It consists of a curved incision, with its concavity downwards, passing along the superior curved line of the occipital bone, and from its centre passes down a vertical incision as far as is necessary in order to reflect the muscles from the posterior aspect of the atlas. A considerable mortality is associated with this operation owing to the close proximity of the vital centres; rapid relief of tension produces serious shock, and it is well sometimes to delay the opening of the dura.

Tumours of the Hypophysis Cerebri or Pituitary Body may affect the anterior or posterior portion. Most frequently the affection is an adenoma with cystic degeneration (resembling somewhat a goitre), but malignant disease is not unknown. Increased functional activity of the anterior lobe results in hyperpituitarism or acromegaly (p. 588); defective activity causes hypopituitarism, as manifested by an increased deposit of fat in the body, together with loss of function or an infantile condition of the genital organs. In women amenorrhœa is usually present. These conditions may follow extrinsic pressure on the hypophysis, as well as intrinsic growths. The close proximity of the optic chiasma explains the association of these phenomena with varying forms of visual disturbance, most commonly with bilateral temporal hemianopsia.

Operative Treatment has been successfully undertaken in a number of cases. Von Eiselsberg* reports sixteen operations with four deaths, and certainly one cure of seven years' duration. The growth is approached through the nose by chiselling away the posterior wall of the sphenoidal sinus.

The Surgical Treatment of Epilepsy.

It would be waste of time to discuss the many surgical procedures which have been suggested in this connection, mainly with the idea of modifying the cerebral circulation. The only operation now seriously considered is that dealing directly with the cerebral cortex, a proceeding dependent on the supposition that the epileptic convulsion is a symptom, and not in itself a disease, and that it results from an irritable condition of the cortex, which may be excited into convulsive activity by various stimuli, originating either in the brain or elsewhere. Sir Victor Horsley† classifies epilepsy as follows:

(1) Idiopathic (with no gross lesion).
    (*a*) Onset localized (focal).
    (*b*) Onset generalized.
(2) Jacksonian (always some gross lesion or traumatism).
    (*a*) Traumatic (with local or general convulsion).
    (*b*) Congenital.
    (*c*) Neoplastic (tumour, abscess, aneurism).
(3) Reflex (injury of spine, nerves, etc.).
(4) Hystero-epilepsy.

As regards the characteristic symptoms and pathological phenomena found in many of these conditions, students must refer to medical text-books.

Before discussing the individual groups from the surgical standpoint, one or two general considerations must be noted. In the first place, the prognosis is gravely modified by the length of time that the epileptic habit has persisted, and if traumatic cases have lasted two years the outlook is very unsatisfactory. A careful study should also be made of the family history as to the existence or not of a neurotic predisposition; in many cases of traumatic epilepsy this is well marked, and then the outlook is correspondingly bad.

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* Von Eiselsberg: Report of the International Medical Congress, London, 1913. Section VII., Pt. II.

† *Trans. Medical Society of London*, February 9, 1903.

It is now generally recognised that operation is useless in the **idiopathic** variety, even when the onset is accompanied by focal symptoms.

Congenital epilepsy is often more or less of the Jacksonian type, and usually depends on some injury sustained during birth. It is frequently associated with other evidences of cerebral mischief (spasm, paralysis, etc.) and with defective growth. If taken early, and if the convulsions still remain localized, some good may follow operation; but if allowed to persist too long, the disease is irremediable by surgical means.

When due to *tumours, abscess*, etc., epilepsy is accompanied by other manifestations, which should guide the surgeon to a correct opinion as to the nature of the case and the operative outlook.

Reflex epilepsy is rare, and may perhaps be cured by dealing with the causative focus. As regards **hystero-epilepsy,** the surgeon must never be tempted to undertake such a measure as double oöphorectomy, which has been tried again and again, and found wanting.

Traumatic Epilepsy is the term applied to an epileptic condition resulting from injuries. It may arise from any of the following conditions: (1) A neuralgic and irritable cicatrix in the scalp; (2) a slight unrelieved depression of the skull; (3) excessive formation of callus after a fissured fracture, or chronic thickening of the bone from osteitis after a contusion, whereby the dura mater is pressed upon and irritated; (4) chronic meningitis, usually associated with an adherent cicatrix in the brain, and particularly liable to occur in syphilitic patients; (5) a single depressed spicule of bone projecting into the cerebral substance.

The **Symptoms** produced are epileptic seizures of the Jacksonian type, the exact manifestations varying with the portion of cerebral cortex which is involved. Localization of the lesion depends partly on the character of the aura, partly on the associated symptoms, such as a fixed headache or the presence of a cicatrix. The convulsions are localized to begin with, but often become general.

Operative Treatment is only applicable in those cases in which the convulsions remain localized; general convulsions place the patient in the category of idiopathic epileptics with a focal onset. The skull is opened over the site of the supposed injury, and it may be that some depressed fragment or spicule of bone is found; it will, of course, be removed. If, however, nothing is found but an adherent cicatrix between the membranes and the underlying brain, it is still an open question as to whether the surgeon should proceed further. In a considerable number of cases the cicatrix and underlying brain substance have been removed; the fits ceased for a time, but in most instances recurrence followed sooner or later from the formation of a fresh adherent cicatrix. Possibly the introduction of a sheet of sterilized gold or silver foil between the brain substance and the membranes might suffice to prevent this occurrence. The locality of the lesion has a considerable influence, according to Horsley, on the result, since the prognosis is good in the motor area, middling in the sensory (parieto-occipital) region, and bad in the frontal. The obvious difficulty of dealing with epileptic conditions emphasizes the statements already made (p. 739) as to the importance of dealing with all depressed fractures of the skull, simple or compound, slight or severe, by immediate operation, so as to prevent, as far as possible, the development of the mischief. When there is a history of tubercle or syphilis, or of both, medicinal treatment directed to the absorption of cicatricial tissue should certainly precede operation.

Traumatic Insanity is sometimes produced by slight depressions or lesions, similar in nature to those causing epilepsy, and can occasionally be relieved by operation. Certainly, when a distinct history of injury precedes the mental aberration, and when there is any localizing lesion or symptom, an exploratory operation is justifiable, and in a number of cases excellent results have followed. The type of insanity is not constant, but varies with the condition and environment of the individual.

Hernia Cerebri.

By hernia cerebri is meant a protrusion of the brain substance through an *acquired* opening in the skull. It thus differs from an encephalocele, which consists in the protrusion of brain substance through some *congenital* defect.

It is always an evidence of increased intracranial pressure, and may be looked upon as Nature's safety-valve for the relief of com pression. It is met with in two distinct forms:

1. When a decompression operation has been performed for a cerebral tumour. The brain substance protrudes through the opening under the scalp, and by this means a temporary relief of intracranial tension is brought about, the patient's life prolonged, and possibly consciousness for a time restored. The tumour, however, continues growing, and sooner or later the patient dies comatose, unless the tumour is inflammatory and disappears.

2. The other variety, due to a compound depressed or punctured fracture, is the result of infection in the underlying brain substance, and the increased pressure within the skull thereby induced leads to a protrusion of inflamed and œdematous cerebral tissue through the wound in the dura, which is usually of small size. The tumour is soft and dusky in colour, and pulsates synchronously with the heart, the pulsations being often evident to the naked eye, and it usually increases in size somewhat rapidly. At first the mental condition of the patient is unimpaired, but sooner or later coma follows, if the hernia progresses, ending in the patient's death. To begin with, the mass consists mainly of œdematous granulation tissue covered by blood-clot, without much brain substance, but later on cerebral tissue itself may protrude. The condition is usually fatal, though

recovery is occasionally seen **Treatment.**—Prevention of this affection must always be aimed at by endeavouring to render any wound involving the meninges aseptic and providing for drainage. Punctured wounds and depressed fractures of the skull, even when giving rise to no urgent symptoms, should always be operated upon, since free relief of tension may prevent the formation of a hernia cerebri, even should absolute asepsis not be attained. If, however, protrusion occurs, it may be possible in a few cases to apply a dry dressing and elastic pressure, and thus prevent it increasing in size; this, however, must not be attempted when the inflammatory symptoms are at all marked. In such cases it is of little use to slice off the tumour and apply pressure, and possibly the best treatment that has been suggested is to paint the projecting mass once or twice a day with absolute alcohol, which is an efficient antiseptic, and also tends by its dehydrating power to diminish the size of the hernia. If such treatment is successful, the tumour slowly granulates over and cicatrizes. Traumatic epilepsy may, however, ensue.

CHAPTER XXVIII.

AFFECTIONS OF THE LIPS AND JAWS.

Affections of the Lips.

Hare-Lip.—By hare-lip is meant a congenital fissure of the upper lip, which may extend for a variable distance through the soft tissues alone, or may also implicate the bony alveolus and the floor of the nose, and extend backwards through the palate. The name is not a good one, since a hare's lip is cleft in a Y shaped manner, the fissure being central below, and bifurcating above into each nostril.

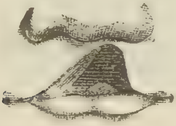

FIG. 371.—SINGLE INCOMPLETE HARE-LIP, INVOLVING MERELY THE TISSUES OF THE LIP, AND NOT EXTENDING INTO THE NOSE.

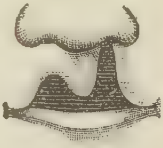

FIG. 372.—DOUBLE HARE-LIP: COMPLETE ON THE LEFT SIDE, INCOMPLETE ON THE RIGHT.

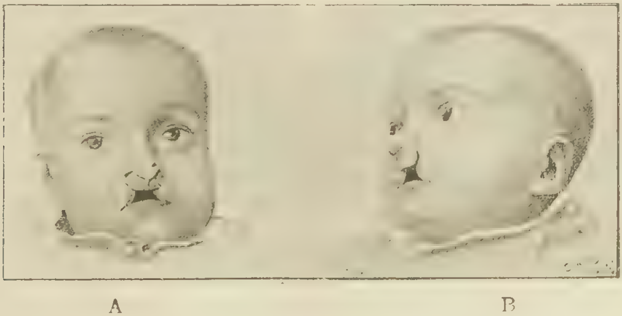

FIG. 373.—DOUBLE COMPLETE HARE-LIP, WITH DISPLACEMENT FORWARDS OF THE CENTRAL PORTION OF THE INTERMAXILLA (OS INCISIVUM).

A, Front view; B, seen in profile.

Varieties.—A hare-lip is *complete* or *incomplete*, according to whether or not it extends into the nostril. It is termed *simple* if limited to the soft parts; *alveolar*, if the bony alveolus is also involved; *complicated*, if associated with a cleft palate. The defect may exist on one or both sides of the middle line; if *unilateral* or single, it is most common on the left side, in the proportion of two to one; if double or *bilateral*, it is usually, but not invariably, alveolar, and accompanied by a complete cleft of the palate. The central portions of the lip and alveolus (os incisivum) may retain either their normal position, or, as is more frequently the case in the bilateral type, project forwards at the end of the nose, forming a proboscis-like appendage (Fig. 373, A and B); its base of support is often thin and elongated, so that lateral mobility may be obtained. Even in simple cases the nose is deformed, being broad and flattened, a condition which becomes much more marked when the alveolus and floor of the nose are widely fissured. Hare-lip is not uncommonly associated with other deformities—*e.g.*, spina bifida and talipes—and it is frequently transmitted from one generation to another. Occasionally a thin red line, as of a cicatrix, is seen occupying the position of a hare-lip cleft, and is probably due to a persistence of the raphe of union of the labial segments; a

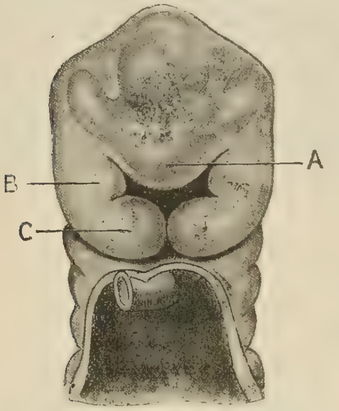

FIG. 374.—HEAD OF FŒTUS OF ABOUT FIVE WEEKS, FROM VENTRAL ASPECT (AFTER HIS), SHOWING THE PRIMITIVE STOMODÆUM BOUNDED ABOVE BY (A) THE UNDIVIDED FRONTO-NASAL PROCESS, LATERALLY BY (B) THE MAXILLARY, AND BELOW BY (C) THE STILL SEPARATE MANDIBULAR PROCESSES.

The quinque-radiate appearance is well represented.

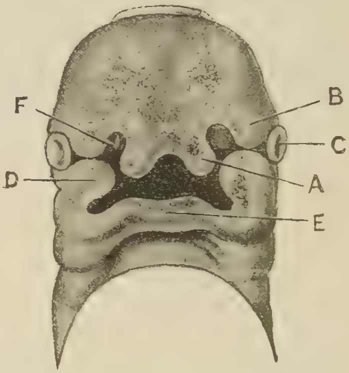

FIG. 375.—HEAD OF FŒTUS OF SIX TO SEVEN WEEKS, FROM THE VENTRAL ASPECT. (AFTER HIS.)

The mandibular processes (E) have now united; the ocular vesicle (C) is seen on either side towards the upper end of the orbito-nasal fissure, and the fronto-nasal process has developed (A) internal and (B) external nasal processes on either side of (F) the still unclosed anterior nares; (D) maxillary process.

slight groove in the alveolus may also be observed at a corresponding point.

Development.—The bony and fleshy parts of the face originate from the outgrowth of processes around the cavity formed by the bending forward of the primitive cerebral vesicle over the end of the notochord. At about five weeks after conception the primitive buccal cavity or stomodæum has a quinque-radiate appearance, due to the manner in which these processes are formed (Fig. 374). A broad median lappet (fronto-nasal process, A) descends from above; this is separated by a fissure on each side from the symmetrically placed maxillary processes (B), and these again below from the more prominent mandibular processes (C), which early unite across the middle line, to form the lower jaw. The fronto-nasal process soon, however, changes. On either side of a slight depression in the median line is placed the internal nasal process or globular process (Fig. 375, A), from which are produced superficially the central portion of the upper lip, and from its deeper aspect the intermaxilla, which divides into the two incisive segments, each carrying the germ of an incisor tooth. Separated from this by a hollow (F), which subsequently forms the anterior nares, is the rounded external nasal process (B), from which develop the side of the cheek and the ala nasi. External to this a fissure (naso-orbital) runs up to, and even beyond, the primitive eye (C), and this is later on closed by amalgamation of the internal and external nasal processes on the inner side with the adjacent maxillary process on the outer (D), except in the deepest part, which constitutes the nasal duct. The integrity of the upper lip is obtained by the union of the lower parts of the internal nasal and maxillary processes, which thus exclude the external nasal from participation in its free border. It is doubtless owing to this arrangement that the sulcus or depression around the ala nasi constitutes such a distinct and characteristic feature of the face. At the same time the deeper parts of these nasal processes are uniting with one another and with the palatal plates, which grow horizontally inwards from the under side of the maxillary processes, uniting in a Y-shaped suture, the point of junction of the limbs being situated at the anterior palatine canal. The union of all these elements is taking place from the sixth to the tenth week, and by that date even the uvula, the last part to unite, should be complete.

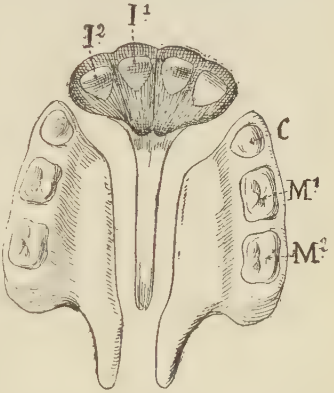

Fig. 376.—Diagram to Represent the Situation of the Cleft in Alveolar Hare-Lip.

I^1, I^2, Incisors; C, canine tooth; M^1, M^2, first and second molars.

Ordinary hare-lip is due to a failure of union of the internal nasal process with the structures in external relation with it; if limited to the soft parts (simple hare-lip), the cleft runs between the internal nasal and maxillary processes; if complete or alveolar, between the same two below and superficially, but in addition between the internal and external nasal processes above and on the deep side. The cleft in the alveolus passes between the intermaxilla and the maxilla (Fig. 376). The relation of the cleft to the teeth varies somewhat, since the germ of the lateral incisor may be developed on one or other side of the suture between the maxilla and intermaxilla, or may even lie between the segments. Hence the lateral incisor is sometimes found on the outer side of the cleft, sometimes on the inner; moreover, an accessory incisor is occasionally developed on the inner side of the cleft.

The os incisivum, or projecting portion of the intermaxilla, usually consists of two segments of bone, united in the median line, and in a child most frequently contains only the two milk central incisors and the rudiments of the two permanent ones; occasionally, as we have just stated, there may be an extra tooth developed on one or both sides of the process.

A simple hare-lip does not interfere seriously with the infant's nutrition, but when double, and especially if associated with a cleft palate, considerable trouble may arise, thus necessitating surgical treatment as a life-saving measure at a very early date. It must also be remembered that all movements of the face—*e.g.*, in crying or laughing—exaggerate the deformity from the unbalanced action of the divided orbicularis oris and other muscles.

As to the *period* at which to operate, it is better to allow the infant to get over the shock of its entrance into the world and become acclimatized to an independent existence, whilst at the same time the operation should be performed before the troubles of dentition begin. From six weeks to three months is perhaps the best age for operation—in well-nourished and healthy children at the earlier date, in poorly-fed and weakly children at the later, unless the inanition is due to the difficulty of feeding the infant owing to the deformity. Under such circumstances the operation may have to be undertaken within the first three weeks.

Operation for Single Hare-Lip.—The child should be laid on an operating-table with its arms bound to the body. The surgeon stands behind it, the anæsthetist and assistant one on each side. The operation may be described in three stages:

1. The *lip* is thoroughly *dissected up from the maxillæ* and alveoli by cutting through the reflections of mucous membrane and the attachment of the muscles and other soft parts. This is mainly needed on the outer side, and where there is much flattening of the nose the ala nasi will also require to be separated. This may cause some amount of bleeding, but sponge pressure easily controls it.

2. The *edges of the cleft* are then *pared.* Many different methods have been employed to accomplish this, but it is only necessary to mention two. The object to be attained is the union of the cleft lip by means of a cicatrix, which shall be as unobtrusive as possible, whilst the red margin must be continuous, and the section such that the raw surfaces are larger than are absolutely necessary, so as to allow for subsequent cicatricial contraction without the development of a notch. The methods recommended are as follows:

(*a*) The incision extends from the apex of the cleft, or from within the nostril, in a crescentic manner (Fig. 377), so that a slight angular projection is formed to constitute a prolabium. This is done on each side, and where the nose is much flattened, more tissue is removed on the outer than on the inner side, so that when the parts are sutured together the nostrils become as nearly as possible symmetrical. By this means the depth of the lip is increased to allow of subsequent contraction, whilst the red margin can be made continuous.

(*b*) *Mirault's Operation* (Fig. 378).—The inner margin and apex of the cleft are pared, so as to leave a raw surface; a flap of red marginal tissue, as thick as possible, is then cut from the outer side, and implanted on the bevelled raw surface of the red margin on the inner side, the upper portions of the cleft being also apposed.

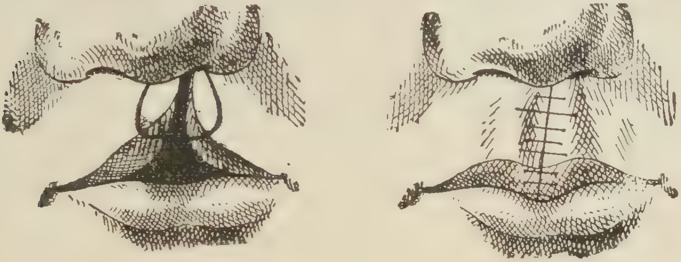

FIG. 377.—ROSE'S OPERATION FOR SINGLE HARE-LIP.

On the left side the semilunar incisions are seen extending as far as the free borders of the lip. The right-hand figure shows the parts drawn into position; the wide cross lines represent the wire sutures, the narrow ones the catgut or horsehair stitches.

3. *Sutures* are now inserted to maintain the lip in the position into which it can be drawn by the fingers without tension. Two deep silver-wire sutures should be introduced, one just above the red margin, and one close to the nose, to draw into position and steady the nostril, which should be left smaller than that on the other side,

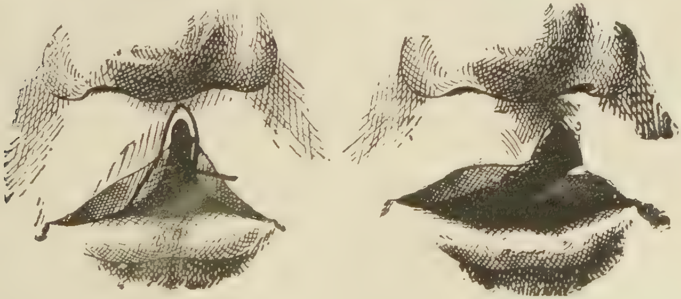

FIG. 378.—MIRAULT'S OPERATION FOR HARE-LIP.

In the right-hand figure the prolabial flap is shown ready to be implanted on the prepared inner side.

so as to allow for subsequent dilatation, which is certain to occur. Horsehair or catgut stitches are used to bring the exact margins together, the continuity of the muco-cutaneous line being accurately preserved, and the cut edges of the mucous membrane upon the deeper aspect being sutured, each stitch, after it is tightened, being used to elevate and evert the lip, and thus assist the insertion of the next. The wound is dressed with a small piece of gauze, and secured by another dry piece cut in the shape of a butterfly, so that the narrow body shall fit over the lip, and the wings spread over the cheeks; this is fixed by collodion, and maintained for some days after the stitches are removed, the deep ones on the fourth day, and the superficial ones about the eighth or tenth. Careful feeding by spoon is necessary, the mother's milk being drawn off and given in this way if possible. In simple cases the child may be returned to the breast about the fifth day. In order to prevent the child from picking at the lip or disturbing the dressing, it is well to put a splint on the flexor side of each arm to control the elbow-joint.

The **Treatment of Double Hare-lip** may be discussed under two eadings, viz., the treatment of the os incisivum, and that of the soft parts.

The os incisivum need not be touched if it retains its normal position, and the labial clefts are then alone dealt with; but if it projects forwards, as is often the case, it must be either removed, replaced, or reduced in size. (*a*) In bad cases where there is much projection the process must be removed. The central portion of the upper lip is freed from it by dissection, and the base of the process divided with cutting-pliers; a small artery in the bone will spurt vigorously, and may need an application of the cautery to stop it. The operation on the lip is deferred till ten days later. A certain amount of deformity from dropping back of the upper lip is certain to result, but can be in measure obviated by adding a projecting cheek-plate to that which carries the artificial incisors. (*b*) Reposition may be effected by several methods, the best of which is Bardeleben's, who incises the lower border of the septum, strips off the muco-periosteum from either side, and then bends or breaks the bone back into position, fixing it by silver wires, and uniting the lip at once to form a splint to maintain it *in situ*. The advantages

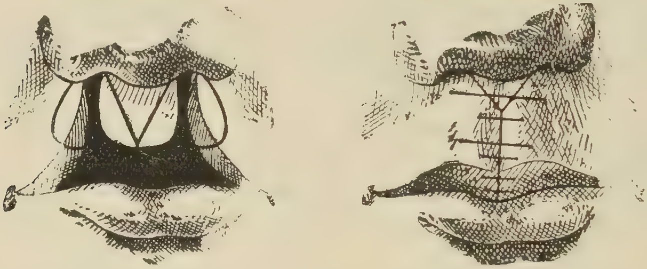

FIG. 379.—ROSE'S OPERATION FOR DOUBLE HARE-LIP.

The central tubercle is pared in a V-shaped manner, and the lateral segments by curved incisions, extending to the red margin, and then inwards. Only the apex of the central portion is included in the completed lip. The long cross lines represent the position of the wire stitches, the shorter ones of the catgut sutures.

claimed for reposition are that the patient retains his own central incisor teeth, and that the normal contour of the jaw and face is not interfered with. Against this plan, however, must be placed the facts that the bone rarely becomes firmly united, that the teeth are stunted and erupt obliquely backwards from rotation of the process, and that its presence prevents the maxillæ from falling together and increases the difficulties of subsequently closing the palatal cleft. By dividing the septum parallel to the plane of the palate, the process can be slid back, and its rotation is thereby avoided. (*c*) Where, however, the projection is not great, it is possible to diminish the size of the os incisivum by gouging away the teeth contained within it, so that the lip can be closed over it.

The soft parts of the lip are dealt with in much the same way as in single hare-lip. They are freely detached from the maxillæ, and the edges pared, as shown in Fig. 379, the central portion being cut into a **V**, and no attempt made to incorporate it into the free margin for fear of depressing the tip of the nose, whilst the lateral segments are pared as in the single operation. These latter are now drawn together and united in the middle line below the central portion, so that a **Y**-shaped cicatrix results. One of the deep silver stitches should fix the apex of the **V**; the other should be inserted just above the red margin. The dressing and after-treatment are as in the single operation. For a time the child may have difficulty in breathing owing to the diminution in the size of the oral aperture, but this is obviated by the nurse drawing down the lower lip with the fingers, or by painting it in a vertical direction with collodion.

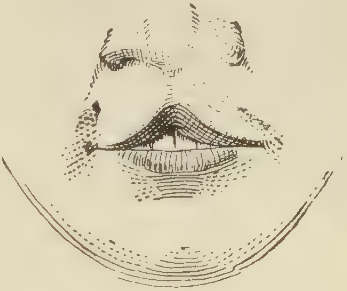

FIG. 380.—MEDIAN HARE LIP.

Median Hare-lip may occur in one of two forms; either a simple cleft exists in the middle line (Fig. 380), or there may be an absence of the intermaxilla and nasal septum, causing flattening of the bridge of the nose, and a broad median defect, flanked by the maxillary portions of the lip.

Oblique Facial Cleft is an uncommon deformity, characterized by a cleft or sulcus in the face, starting from the usual situation of a hare-lip below, but running up outside the nostril to the inner side of the lower lid (Fig. 381). Coloboma of the iris or choroid is sometimes associated with this rare defect. The deformity is due to non-closure of the naso-orbital fissure, and runs along the line of the nasal duct. It may be limited to the soft parts, or may involve the bones, even laying open the antrum.

Macrostoma (Fig. 382) is characterized by an abnormal width of the mouth, and is due to non-union of the maxillary and mandibular processes. It may be uni- or bi-lateral, and is usually associated with anomalies of development of the ear, accessory auricles being often present. As a rule, a small papilla on the upper and lower margins will indicate the true limits of the mouth, being constituted by the points of attachment of the orbicularis. The existence of these is of great importance as indicating the extent to which the cleft must be pared in order to restore the mouth to its normal size.

Mandibular Clefts are exceedingly rare. They are due to non-union of the mandibular processes in the middle line, and involve either the soft tissues of the lower lip alone, or may extend to the bone, and even the tongue. Treatment is as for ordinary hare-lip.

Microstoma is the term applied to a condition in which the fusion of the parts entering into the formation of the lips progresses to a greater extent than usual, so that the oral orifice is contracted. It may be associated with defective development of the lower jaw. In the more severe cases, where the mouth is extremely narrowed, a transverse cut should be made outwards on each side, and the mucous membrane stitched to the skin.

Macrocheilia, or hypertrophy of the lip, occurs in three forms: 1. The congenital variety, a condition analogous to macroglossia, and due to a congenital distension of the lymphatic spaces, or chronic lymphangiectasis, accompanied by overgrowth of the connective tissue. The lower lip is most often involved, and is firm, thickened, and everted, causing considerable deformity. The treatment consists in the removal of a V-shaped portion from the centre. 2. An acquired form occurs in children and young people with a tuberculous inheritance, constituting the so-called 'strumous lip.' Either lip may be affected, but perhaps more frequently the upper; the thickening is due to a chronic lymphangitis, resulting from the absorption of toxic material from persistent cracks and fissures. If these can be healed, and the general health improved, diminution in the size of the lip soon follows. 3. In adults, macrocheilia is in almost all cases due to tertiary syphilis. The lower lip is most often enlarged, and becomes thick and hard. It is due to the diffuse

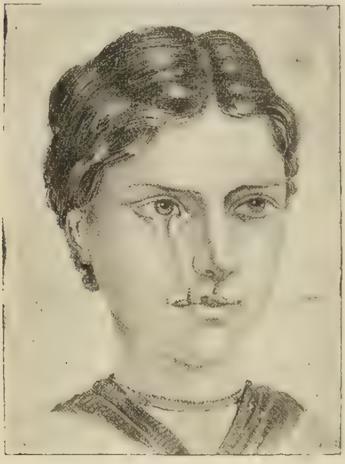

FIG. 381.—OBLIQUE FACIAL CLEFT, OR, RATHER, CICATRICIAL DEFORMITY ALONG THE LINE USUALLY TRAVERSED BY SUCH A CLEFT. (KRASKE'S CASE.)

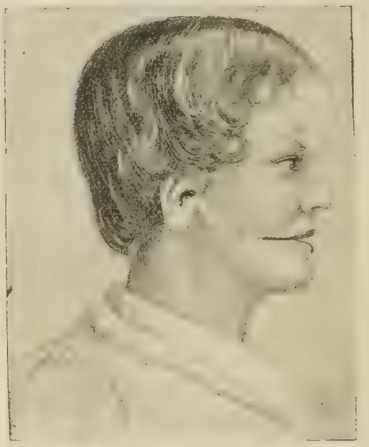

FIG. 382.—MACROSTOMA WITH AURICULAR APPENDAGES. (FERGUSSON.)

sclerosis characteristic of tertiary mischief. General treatment, and not local, is needed.

Syphilitic Affections of the lip are not uncommon. A *primary* chancre may be caused by kissing, or by smoking an infected pipe, or drinking from a glass with an infected rim. It usually presents a smooth ulcerated surface, discharging a small amount of sero-pus, resting on a mass of infiltrated tissue which may extend over the whole lip (Fig. 383). The induration is not so great as in chancres upon the genital organs, but the infiltration is much more extensive. Enlargement of the submaxillary lymphatic glands occurs very early, and the disease usually runs an active course. The treatment is as for syphilis elsewhere (p. 166). A labial chancre may closely resemble epithelioma, but is distinguished from it by its rapid development up to a certain point, by the early implication of the glands, which soon become very large, by the absence of typical cachexia, by the age of the patient, and the course taken by the case, as well as by the local appearances. The surface is usually flattened, and less warty and irregular than in epithelioma, whilst the skin is more involved than the mucous membrane. Moreover, it is more common on the upper lip, whilst epithelioma is usually seen on the lower (compare Figs. 383 and 384). In the *secondary* stage mucous tubercles are frequently met with, involving the inner side of the lip and the angle of the mouth. In the *tertiary* period serpiginous ulceration and gummata may occur, or the diffuse induration described above. In *inherited* syphilis, cracks and mucous tubercles are constantly present, and may be so extensive as to leave cicatrices radiating from the mouth, which are very characteristic (Fig. 173).

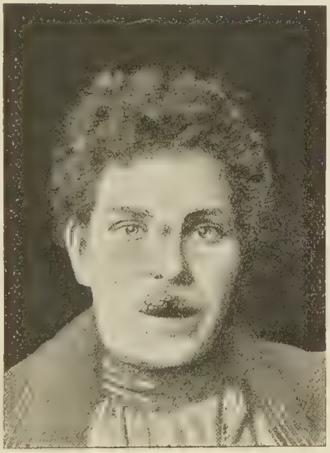

FIG. 383.—CHANCRE OF UPPER LIP. (FROM A PHOTOGRAPH.)
The enlargement of the submaxillary lymphatic glands is very evident.

Cracked Lips (or, as they are often called, *chapped lips*) are usually the result of cold weather, a central crack or fissure forming which is extremely painful, and liable to bleed very readily on everting or stretching the part. The lower lip is that generally affected. In tuberculous children more than one may occur, and by their persistence they give rise to a considerable degree of induration and infiltration, and perhaps lead to glandular trouble. All that is needed in the shape of *treatment* is the application of a little lanoline or cold cream, but if they persist, it may be advisable to touch them with nitrate of silver.

Herpes Labialis is a condition usually associated with catarrh, and not unfrequently with pneumonia or other fevers. Either lip may be affected, and the herpetic eruption is quite limited in extent. It consists of a number of little vesicles situated on a hyperæmic and painful base; after a few days the vesicles become transformed into pustules, and these in turn burst and dry up, the whole affection lasting perhaps a week or ten days. No special treatment is required. If the inner aspect of the lip is affected, the epithelium early becomes sodden and is shed, so that the vesicular stage is much shorter.

Mucous Cysts occur on the inner side of the lip in the form of small rounded swellings, which are translucent and contain a glairy fluid. They are often due to trauma, whereby the opening of a mucous gland is blocked. The whole cyst wall should be dissected out, and the wound closed by stitches.

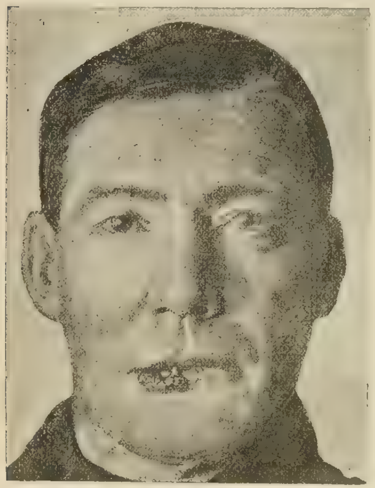

FIG. 384.—CHRONIC EPITHELIOMA OF LOWER LIP. (FROM A PHOTOGRAPH.)

Nævi are frequently met with in the lip. If confined to the inner aspect they may be dissected out, but when large and involving the whole thickness, they should be dealt with by electrolysis.

Warty Growths are often seen on the lower lip, especially near the angle, and may then simulate epithelioma. They are distinguished, however, by the fact that ulceration is not often present, that the lymphatic glands are not involved, and that there is but little infiltration of the base. They should, however, be removed as early as possible, since malignant disease often starts from them.

Epithelioma of the lip usually occurs in men of the working classes, and is commonly due to the irritation produced by smoking a short clay pipe, which is allowed to rest on one or the other side near the angle. A semicircular notch will frequently be noticed in the teeth of the upper and lower jaw, corresponding to the situation of the growth on the lip, and caused by the constant friction of the pipe-stem. It may also start opposite the site of some projecting, rough, or carious tooth. It is but rarely met with in women, occurring in England in not more than 5 to 6 per cent. of the cases, and probably most of these are clay-pipe smokers. It is certainly more common amongst country folk, who use the short clay pipe, than amongst the cigarette and cigar smokers in towns.

The disease may start as an induration around a crack or fissure, which gradually extends, forming a typical malignant ulcer; or as a wart-like growth, which fungates and ulcerates; or as a chronic infiltration leading to an irregular nodulated thickening of the lip, which sometimes looks shrunken and feels sclerosed (Fig. 384).

If allowed to run its course unchecked by treatment, the disease steadily progresses, forming an ulcerated mass of greater or less size, and even involves the jaw. The submental and submaxillary glands are early implicated, and secondary deposits are also found in the glands which accompany the carotid vessels. Beyond this, however, the disease rarely extends, visceral complications being uncommon. Death is generally caused by the secondary growths in the neck, which attain considerable dimensions and then ulcerate, this stage being possibly preceded by one of cystic degeneration. From these ulcerating surfaces a quantity of discharge escapes, the amount varying with the septicity or not of the wounds. Intense pain is caused by implication of nerves, and hæmorrhage is also likely to follow from erosion of the vessels in the neck.

The **Diagnosis** of epithelioma is rarely doubtful, but occasionally warty growths, or even a primary chancre (p. 791), may be mistaken for it. The clinical history generally suffices to determine the nature of the mass, as also the character of the base and the appearance of the parts; but in uncertain cases the removal of a small portion of the edge under cocaine, and its microscopic examination, are required to set doubts at rest.

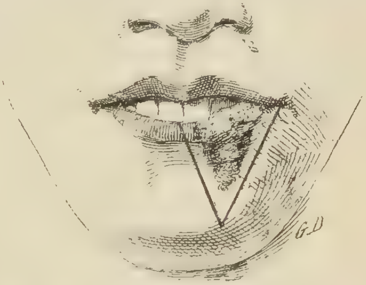

FIG. 385.—V-SHAPED INCISION FOR REMOVAL OF EPITHELIOMA OF LIP.

Treatment.—The primary growth must be excised completely, if such be possible, together with its lymphatic connections, including the submental and submaxillary glands and the deep carotid glands, whether they can be felt enlarged or not. When once the deeper glands in the neck have become palpably enlarged, they often contract such adhesions as to render their extirpation impracticable.

If the growth is limited to one part of the lip, a **V**-shaped wedge extending half an inch beyond it in all directions may be taken away (Fig. 385), and the wound closed, as in a case of hare-lip, without much deformity resulting. When it is more extensive, considerable ingenuity must be exercised in order to make good the defect. One plan that often gives good results is to excise the growth by a somewhat larger **V**-shaped incision, and then to extend the labial fissure transversely to one or the other side, or to both, dissecting up these segments from the bone; the flaps can then usually be brought together, whilst the mucous membrane is united to the skin along the margin of the new lip.

When the whole lower lip requires removal, *Syme's operation* may be performed with advantage. It consists first of all in the complete excision of the diseased lip. Two curved incisions are then made, starting from the middle line of the wound, and extending downwards under the chin, to terminate below the angles of the jaw, an inverted **V**-shaped portion of skin between them remaining fixed to the symphysis menti to form a base of support for the new lip. The lateral flaps are now dissected up, raised, and united one to the other in the middle line, so as to constitute the new lip, an inverted **Y**-shaped cicatrix resulting. The elasticity of the skin in this region allows this to be accomplished, and the whole wound closed, without leaving any part to granulate. The mucous membrane should be finally stitched to the skin over the upper free margin. Healing by first intention usually follows.

If the whole of the upper lip needs to be removed, it may be restored in a variety of ways. Perhaps one of the best consists in making incisions which skirt the alæ nasi on each side, and then extend outwards into the cheeks sufficiently to allow the tissues, when they have been freed from the maxillæ by undercutting, to be drawn together in the middle line. In such cases care must be taken not to encroach on Stenson's duct.

The Extraction of Teeth.

Although this operation is usually undertaken by dentists, yet surgeons and medical practitioners have not unfrequently to perform it, and not a little skill and judgement are sometimes needed in its execution. An anæsthetic may or may not be employed. If merely one or two teeth are to be drawn, gas or chloride of ethyl will suffice; but when a large number require extraction at one sitting, it is better to give ether or the A.C.E. mixture; chloroform should never be administered when the patient is in the sitting position. The posterior teeth are, of course, dealt with first, and subsequently those in front. Suitable forceps are required for the various teeth, and the number of fangs belonging to each must be kept in mind. Incisor and canine teeth are removed by a combination of traction and rotation; the bicuspids and molars by traction combined with lateral movement, especially inwards. The forceps, after being sterilized, should be pushed well up under the gum, and no traction made until a firm grasp has been taken of the neck of the tooth, and the tooth itself loosened by lateral swaying.

Accidents of various types happen from time to time. The crown may break away, leaving the fangs *in situ,* and then each of these must be sought with root forceps and accounted for. In dealing with the first or second upper molar, it is quite possible to drive a fang upwards into the antral cavity, setting up thereby acute suppuration within the cavity. Laceration of the gum is often unavoidable, and injury to the alveolar margin may follow; but such accidents as fracture or dislocation of the lower jaw are certainly avoidable. The use of an elevator is sometimes desirable in order to remove old roots, but it is an instrument that must be used with great care.

After extraction the mouth is washed out with sterilized or carbolized water, and the bleeding usually ceases without delay. If the gum has been much torn, it should be pressed back into position by the fingers, and when the mouth is dirty, it may be desirable to touch the socket over with tincture of iodine. A mouth-wash of boric acid or sanitas is subsequently employed.

Should the *hæmorrhage* continue, as in patients suffering from purpura, scurvy, and hæmophilia, the socket must be carefully plugged with a strip of gauze soaked in a styptic, such as adrenalin or antipyrin; the use of perchloride of iron in this connection is undesirable. Occasionally the bleeding re-starts after two or three days as a result of infection of the socket ; it is then necessary to open up the cavity freely from the outer side, cutting away gum and, if need be, bone, so as to allow free exit to discharges and a more ready access for strips of gauze soaked in styptics or antiseptics.

Affections of the Gums and Alveolar Processes.

Spongy or Inflamed Gums (gingivitis) are not unfrequently caused by a dirty and uncared-for condition of the teeth, the administration of mercury, or scurvy. They are characterized by being soft and congested, bleeding readily on pressure, and perhaps showing signs of ulceration. The teeth are often loose, and may fall out. All that is necessary is the correction of the determining cause and the use of an alum mouth-wash.

Alveolar Abscess (Fig. 386) is almost always associated with suppuration around the fang of a carious tooth, the bacteria finding their way out of the pulp chamber through the apical foramen. The alveolar walls become expanded, and the pus either finds its way over the edge of the bone (C, D), or even through the osseous tissue (A), under the external periosteum. If limited in extent, it perforates the gum directly, and is then known as a gum-boil; but occasionally it burrows beneath the periosteum, which is stripped from the bone, and may thus lead to an abscess of larger size, possibly resulting in necrosis of the jaw. The formation of an alveolar abscess is almost always associated with considerable œdema of the face, pain of a serious character, and when extensive may give rise to marked constitutional disturbance. Sometimes graver complications ensue; thus, in the upper jaw the antrum may be opened, and suppuration in this cavity follow, whilst in the lower the abscess may travel downwards and burst externally, either close to the lower margin of the bone or in the neck. A troublesome sinus results, which can only be cured by the removal of the tooth, and even then a depressed and adherent cicatrix ensues, which is very unsightly. The most essential point in the *treatment* necessarily consists in the removal of the offending tooth. Often this is quite sufficient, and possibly the tooth may come away with an abscess cavity attached to one of the fangs. When suppuration occurs beneath the periosteum, the pain can at first be relieved in measure by fomentations, but as soon as fluctuation is detected a free incision should be made, if possible, through the gum, and the cavity emptied. Possibly it may be wise to keep a small piece of stuffing in for a few hours, but if a large enough opening has been made, all that is subsequently needed is repeated and frequent irrigation, preferably with peroxide of hydrogen. When the skin is thinned and the cheek red, an external incision is usually required, and sometimes this may have to be undertaken as a preliminary, the extraction of the tooth being left until the swelling has somewhat subsided. If a small sinus persists after removal of the tooth, it must be opened up, and any carious or necrosed bone taken away. Not unfrequently the masseter becomes infiltrated and sclerosed when the lower jaw is affected, and this may result in fixed closure of the mouth, demanding operative treatment for its cure.

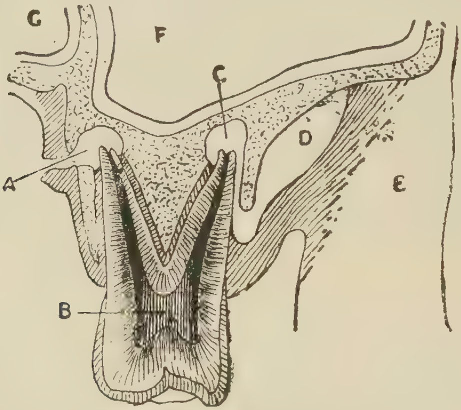

Fig. 386.—Diagram of Alveolar Abscess, resulting from Disease of Molar Tooth. (After the American System of Dentistry.)

A, Abscess arising from escape of septic material from B, the pulp chamber, through the foramen at apex of the fang; it has burrowed directly through the alveolar process and burst through the gum; C, similar abscess, which has tracked down between the tooth and the alveolus, and spread out beneath the alveolar periosteum at D, constituting the typical alveolar abscess; E, cheek; F, antrum; G, nasal cavity.

Pyorrhœa Alveolaris (or **Riggs' Disease**) consists in an inflammatory condition of the margins of the gums, accompanied by a purulent discharge, which arises from pockets or pouches which may extend a greater or less distance along the roots of the teeth. In the early stages the gums are swollen and œdematous to such an extent that they often hide or partially cover the stumps of decayed teeth, and they bleed readily. The tongue is coated, and the breath exceedingly offensive. In less severe cases and in the later stages the tissues of the gums shrink, and, together with the alveolar border, become atrophic; the fangs are thereby uncovered and the teeth loosened, so that after a while a natural cure may be established by the patient becoming edentulous. The process is limited to a few teeth, or may involve many. It is generally preceded by an excessive deposit of tartar, beneath which bacterial infection occurs, the inflammation spreading down along the periodontal membrane, and perhaps extending to surrounding parts—*e.g.*, the maxillary antrum. In most cases, on making pressure along the alveolar margins, a greater or less quantity of pus can be squeezed out. For the constitutional results of this *oral sepsis*, see p. 84.

Treatment must, in the first place, be directed to the teeth, and consists in the removal of tartar and the application of astringents and antiseptics, preferably peroxide of hydrogen, not only to the exposed mucous membrane, but also into the pouches and pockets where pus collects. In some cases it is wise to destroy the granulation tissue forming the outer wall of these pouches by means of the electric cautery, or even to remove the teeth. Too much must not be done at a time, as the general symptoms may be aggravated by an increased absorption of toxins, and the reparative activities of the patient may be very deficient. Goadby* has pointed out that in many of the worst cases the resisting power of the individual, as estimated by the opsonic index, is very low to particular organisms isolated from the mouth, and recommends the employment of a suitable vaccine prepared from these particular bacteria.

Hypertrophy of the Gums is met with in the form of a sessile overgrowth, sometimes almost cauliflower-like, around and between the teeth, which are usually carious; it occurs most frequently in children. In slight cases the overgrowth may be destroyed by the application of a crystal of trichloracetic acid; but in the more exaggerated types excision is required.

Dental Cysts are by no means uncommon, resulting from the irritative effects of dental caries; hence they follow the distribution of that affection, and are most frequently seen in connection with the upper first molars and bicuspids. They develop at the roots of the teeth, causing a painless regular expansion of the bone, free from inflammatory phenomena, unless infected secondarily with bacteria. After a time the centre of the swelling softens, and, as the bony wall is absorbed, parchment-like crackling can be felt; finally, the condition presents as a rounded tense elastic swelling, around the margins of which the remains of the expanded bone can be detected.

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* Goadby: Erasmus Wilson Lecture on 'Pyorrhœa Alveolaris' (*Lancet*, March 9, 1907).

In the upper jaw they often encroach on and project into the bony antral cavity, pushing the mucous membrane in front of it. The tooth which is the cause of the trouble is always dead, and frequently merely a septic root is present.

The *cause* of these cysts is probably the proliferation of certain embryonic remains of the enamel organ, brought about by the irritation of toxic matter which has escaped from the pulp cavity. These fœtal residues are lighted up into activity, developing into masses or columns of epithelial tissue, which undergo cystic degeneration. Their pathogenesis is practically identical with that of the epithelial odontome, but merely one cyst develops here instead of many. The fluid contained therein is thick and mucoid in character, and broken-down epithelial cells and cholesterine are seen in it on microscopical examination.

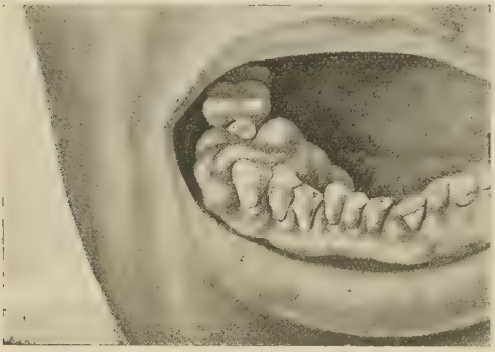


FIG. 387.—SIMPLE EPULIS.

Treatment.—The cyst must be laid freely open into the mouth, the septic tooth or stump removed, and the anterior wall of its alveolus cut away. The alveolus and cyst thus laid into one cavity are scraped so as to remove all the epithelial lining, and packed with gauze so as to ensure healing by granulation. In the upper jaw the utmost gentleness is required in dealing with the deeper wall of the cyst, as the septum between it and the antral cavity may be extremely thin and entirely devoid of bony tissue.

Epulis.—By this term is meant a tumour growing from the alveolar periosteum. Two varieties are described, viz., the simple and the myeloid.

A **Simple Epulis** is usually of a fibromatous nature, and may grow from either jaw, though more commonly from the lower. It is generally due to the irritation of diseased teeth, and although most marked on the outer aspect, it burrows between the teeth, and is also found on the inner side. It appears as a red fleshy mass, smooth or perhaps lobulated (Fig. 387), of an elastic consistency, and possibly associated with a little superficial ulceration. It is covered with mucous membrane, and may contain a few spicules of bone. The *treatment* consists in removing the growth together with the teeth or stumps with which it is connected. If small, it will suffice to cut away and scrape the bone from which it arises; but if large, or if it recurs after such treatment, the portion of the alveolus from which it springs must also be excised. This is best accomplished by extracting a tooth on either side of the tumour, and cutting vertically through each socket with a saw, the two incisions being united below by a chisel, so as to remove a quadrangular portion of bone without interfering with the continuity of the jaw.

Myeloid Epulis.—This title is applied to a myeloma developing from the interior of the alveolar process. It forms a soft, rapidly increasing mass of a dusky purple colour, which runs on to ulceration or fungation; the deeper portions may contain an ossific deposit. As with all forms of myeloid growth, it is only locally malignant. *Treatment* consists in free removal of the tumour and of the portion of alveolus from which it arises. In the upper jaw this sometimes necessitates excision of the complete palatal segment of the maxilla, but in the lower jaw it is generally possible to maintain the continuity of the mandible by removing merely a quadrilateral portion in the same way as for a simple epulis.

Epithelioma and **Sarcoma** (**round** or **spindle-celled**), arising from the gum, are both met with. Epithelioma in this situation occasionally fungates, but more often invades the bony tissues, and in the upper jaw extends upwards to the antrum; hence it is sometimes termed a 'creeping or burrowing epithelioma.' The ordinary signs of this disease become evident, lymphatic glands are enlarged, and typical ulceration of the gum follows. The only possible *treatment* consists in free excision of the growth, together with the portion of bone affected and the lymphatic area involved.

Necrosis of the Jaw.—**Causes**: (1) Subperiosteal alveolar abscess, connected with dental caries. (2) Traumatism, such as blows on the jaw, with or without fracture, in the latter instance being due to infective periostitis or osteo-myelitis, owing to the lesion becoming compound. The use of dirty forceps or elevators in extracting a tooth may similarly light up an infective inflammation, resulting in necrosis. (3) In tertiary syphilis necrosis also occurs, affecting most frequently the palate or alveolar borders. (4) It results from mercurial poisoning, but rarely at the present day. (5) Phosphorus necrosis is met with amongst those who work in lucifer-match factories, but only when ordinary phosphorus is used; the amorphous form is harmless. The fumes are supposed to gain access to the jaws through carious teeth, giving rise to a somewhat acute inflammation, which terminates in necrosis. A considerable amount of new bone forms beneath the periosteum, and the sequestrum, which is curiously gray and porous, like dirty pumice-stone, is always slow in separating. Either jaw may be affected, but perhaps the lower a little more commonly than the upper. (6) Necrosis may follow one of the exanthemata or any condition of malnutrition or anæmia, arising as an infective idiopathic or embolic osteo-myelitis, and then probably affecting a considerable extent of bony tissue, possibly the whole mandible. (7) Tubercle is occasionally responsible for this condition.

The symphysis menti in children is occasionally the seat of a pyogenic or tuberculous infection, previous to the eruption of the permanent incisors. An abscess forms, and caries or a limited necrosis results. In a case of this type an opening is required in the submental region, through which the diseased tissue can be thoroughly scraped away. The teeth are of course lost, but a good result, and with but little scarring, may be anticipated.

The **Clinical Phenomena** associated with necrosis of the jaw are necessarily much the same whatever the cause. The acute form commences with severe pain in and around the jaw, followed by great swelling of the face and difficulty in opening the mouth or taking food. The temperature is raised, and even rigors may be present; the breath is usually foul. Sooner or later an abscess forms, which may point either in the mouth or on the face, or the pus may burrow downwards for some distance into the neck. Sinuses persist, discharging the most offensive pus; a new covering of bone sometimes forms in the lower jaw, enclosing a sequestrum, but in the upper this is rarely noticed, and even in the lower it is not unusual to see a considerable amount of bare or dead bone absorbed without the formation of an involucrum.

Treatment.—In the early stage the cheek should be fomented, but as soon as there is any suspicion of pus a free incision is made down to the bone inside the mouth and along the line of reflection of the mucous membrane. When necrosis is present, it must be treated in the ordinary way, the sinuses being flushed out with an antiseptic solution three or four times a day until the sequestrum is loose; it is then removed, if possible, from within the mouth. Drainage by means of an external opening is often absolutely necessary. In the worst cases necrosis may extend from the middle line of the mandible to the temporo-maxillary articulation; it is then wise to make an external incision, and remove the bone *in toto* after detaching it by saw from the other ramus.

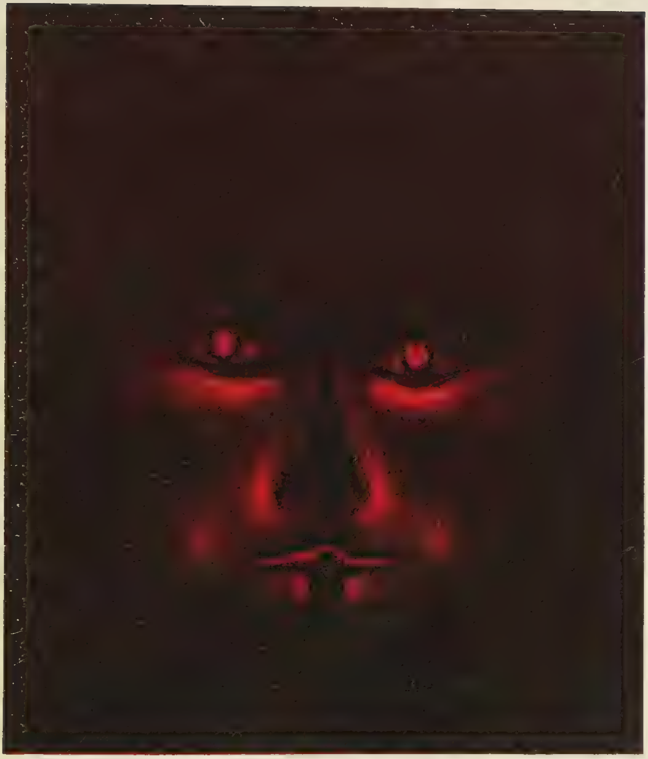
Affections of the Antrum

Suppuration within the Antrum (*empyema of maxillary sinus*) frequently arises from disease connected with the fangs of the first or second molar or bicuspid teeth; it not uncommonly results from an acute inflammation of the nasal cavities as in influenza, and may then be associated with trouble in the other accessory nasal sinuses, such as the frontal and ethmoidal (p. 821); it is occasionally lighted up by injury. In chronic cases it is not unusual to find the antrum filled with soft polypoid granulations.

The **Symptoms** produced are often extremely equivocal, and the condition may be present for some time without being recognised.

In the *chronic* forms all that is noticed may be an intermittent discharge of pus into and from one side of the nose, associated perhaps with some pain in the infra-orbital region, a chronic cough, and an irritable throat. The pus varies considerably in amount and character. being sometimes extremely offensive. On holding the

PLATE V.



Transillumination of the face.

[To face page 800.

patient's head forwards, it can be demonstrated that there is an overflow of pus into the nostril, and sometimes when the patient reclines it flows back into the pharynx. Should the opening into the nose become blocked, all the symptoms are aggravated, the pain becoming more marked and the swelling increasing. *Signs of distension* of the antrum may also be produced in this way, and are manifested in four directions: (*a*) Inwards, causing obstruction to nasal respiration, and possibly epiphora, from compression of the nasal duct; (*b*) upwards, leading to protrusion of the eyeball or exophthalmos; (*c*) downwards, resulting in depression of the side of the palate, and possibly irregularity in the line of the teeth; and (*d*) outwards, giving rise to a somewhat characteristic projection of the cheek beneath the malar eminence Under these circumstances, a finger inserted into the mouth, between the cheek and the bone, will detect a loss of resistance in the anterior wall of the antrum, and if the distension has lasted long, eggshell crackling may be noticed, or the whole anterior wall may be absorbed and an elastic swelling take its place. Infra-orbital neuralgia is often a marked feature in these cases.

In *acute* cases all the above phenomena may be present in an accentuated degree, accompanied by severe tensive pain and some amount of febrile disturbance. Necrosis of the lining bony walls may also be induced, owing to the fact that the mucous membrane is closely adherent to the periosteum.

The **Diagnosis** of suppuration within the antrum is not always easy. The periodic discharge of pus from the nose is suggestive, as also the presence of a dead or painful molar or bicuspid tooth. If a flow of pus can be induced by change of position of the head, it is pathognomonic of suppuration within one of the accessory sinuses connected with the nose, probably of the antrum. If, after the nose has been cleared and the head hung down, pus is seen welling up from under the middle turbinal, the diagnosis is almost certain. *Transillumination of the antrum* may confirm this opinion. A suitable electric lamp is placed within the mouth, and if the patient is in a dark room, or if he and the surgeon are under a photographer's cloth, and his antra are normal, the cheeks, lips, and lower margins of the orbits become of a rosy-red colour (Plate V.). If, however, the cavities are occupied by pus, blood, or a growth, the parts remain dark. Transillumination does not answer in every individual, and hence the value of the test is much diminished. The presence of illumination excludes intra-antral growths or abscess, but its absence, unless unilateral, is not of much significance. Finally, the antrum may be punctured with trocar and cannula through the canine fossa, or through the inferior nasal meatus, and an absolute diagnosis obtained by washing it out.

The **Treatment** necessarily varies with the type of the disease. It must always be remembered that the orifice of the antrum into the middle meatus is an inch above the antral floor, and hence the natural drainage is very defective (Fig. 396).

In the early active form that sometimes follows the extraction of a tooth, and may even be associated with the pushing up of a broken fang into the cavity, it will probably suffice to enlarge the opening in the alveolus with a suitable antrum drill. A solid rubber plug is introduced, and the cavity washed out into the nose with sterile salt solution two or three times a day, until the purulent discharge ceases, when the opening may be allowed to granulate. The solid plug is better than a hollow tube, which permits discharge to get into the mouth, and food or septic material to pass up into the antrum.

In the acute post-influenzal cases the cavity may be washed out from the nose, the inner wall being punctured, after efficient cocainization, through the inferior meatus; this lavage may be required at first daily, but subsequently less frequently, and in the intervals the patients must be guarded from cold. Sometimes a change of air will clear up the trouble.

In the more chronic cases, intranasal treatment will usually suffice, but to be effective the greater part of the inner (nasal) wall of the antrum must be removed so as to leave a large communication through which the cavity can be cleansed. Sometimes there is a large accumulation of polypoid granulation tissue within the antrum, and to remove it the surgeon must make an additional opening by dividing the mucous membrane above the first molar tooth and take away the anterior bony wall. Effective curetting can then be performed, and it is usually possible to close the buccal opening. Only in very old-standing neglected cases is it necessary to utilize the old-fashioned method of packing the antrum from the buccal aspect and making it heal by granulation. It is important in these cases to make certain that the trouble is limited to the antrum, and not dependent on the overflow into it of pus from other accessory sinuses.

Hydrops Antri is the term applied to a chronic distension of the antrum with a glairy mucoid fluid, somewhat similar in character to that contained in a ranula. The condition is painless, and free from inflammatory phenomena, and as the expansion increases, eggshell crackling of the anterior wall, or even distinct fluctuation, may be observed. It was formerly supposed to arise from obstruction to the aperture into the nose and retention of secretion, but is in reality due to a cystic tumour forming from the glands of the mucous membrane, or more often to a dental cyst (p. 797) which has encroached on the antral cavity; rarely is it due to the presence of a dentigerous cyst (p. 808). The *treatment* required is to open thoroughly the cyst from the mouth after dividing the mucous membrane, subsequently removing a sufficient portion of the anterior wall to enable it to be washed out and drained. It is sometimes possible to remove the whole lining membrane without wounding the mucous membrane of the antrum

Various **Tumours** may originate in the antrum—*e.g.*, mucous polypi, fibromata, odontomata, osteomata, sarcomata, and cancers. If limited to the cavity, they produce no definite symptoms, except when large enough to cause expansion of its walls. Malignant growths, however, generally pass beyond the limits of the antrum, and lead to the usual signs of malignant disease of the upper jaw. *Treatment* consists in removing simple growths, if possible, without interfering with the integrity of the maxilla. This may be accomplished by reflecting the overlying cheek, as in excision of the upper jaw. For malignant tumours, removal of the complete upper jaw on the affected side is probably the only remedy.

Tumours of the Upper Jaw.

Many of the **Simple Tumours** springing from the upper jaw have been already described amongst those involving the alveolar border and antrum. Only a few remain to be dealt with.

Osteoma occurs either in the form of a tumour composed of compact tissue, then usually growing within the antrum; or occasionally as a diffuse symmetrical overgrowth, constituting the condition known as *leontiasis ossea*. A few cases of **Chondroma** have also been reported.

Leontiasis ossea is a disease, fortunately very rare, which, commencing in young adult life, progresses slowly, but relentlessly, and may at length destroy the patient after causing a great amount of suffering. Nothing is known as to its origin. It affects either the cranial or facial bones, or both, and consists in a development therefrom of nodular masses of soft spongy bone, embedded in which are areas of fibrous tissue. When affecting the facial bones, the projections may become very marked, and give the patient a hideously repulsive appearance, with a more or less leonine aspect. As growth progresses, the new bone encroaches on the cavities of the skull, the antrum, the orbits, or even the cranial cavity, and thus exophthalmos, neuralgia, and finally coma may be produced. No satisfactory treatment is known, although attempts to chisel away the masses have been made.

Malignant Disease of the Upper Jaw occurs in the form of sarcoma or cancer. *Sarcoma* is perhaps the more common, and originates either from the anterior wall, from the cavity of the antrum, from the spheno-maxillary fossa behind the bone, or may extend into the maxilla from the naso-pharynx. Not unfrequently these growths have a considerable ossific basis, and this is sometimes so extensive as to obliterate the antral cavity, and convert the bone into a solid mass. *Cancer* develops in the form of a squamous burrowing epithelioma, springing from the gums; or as a columnar or acinous cancer starting in the glandular tissue, found both in the nasal and antral cavities. It is probable that not a few of these growths, both sarcoma and carcinoma, are derived from embryonic rests, associated with the enamel organs and teeth, and, as Sir F. S. Eve* points out, are in reality malignant odontomata.

The **Clinical Features** of both forms of malignant disease are practically identical.

If arising *from the anterior aspect* of the bone, a tumour is produced which projects under the cheek, the tissues of which are invaded by it; it extends down towards the mouth, and is readily detected through the mucous membrane. It may, however, spread deeply, and involve the cavity of the antrum. It causes no obstruction to nasal respiration, and no epiphora except in the later stages.

If it originates *within the antrum*, the usual signs of distension of that cavity (p. 801) are produced, associated with a foul, and often blood-stained, discharge from the nose, within which the ulcerated surface of the growth may be seen. Epiphora is caused by pressure on the nasal duct, whilst the growth has been known to burrow upwards along this passage and project near the inner canthus. The passage of air through the nose on that side is also impeded, and the palate may be depressed.

If the growth commences *behind the maxilla*, it usually springs from one of the walls of the spheno-maxillary fossa, or from the base of the skull, and is then characterized by a great tendency to spread in all directions. It may push the whole bone bodily forwards without encroaching upon the antrum; sometimes it finds its way outwards to the pterygoid fossa through the pterygo-maxillary fissure, or inwards to the nose through the palatine foramen, or even up into the orbit; whilst more rarely it spreads down along the posterior palatine canal, so as to appear at the postero-external corner of the palate; in the later stages the antral cavity is also involved, and even the base of the skull eroded.

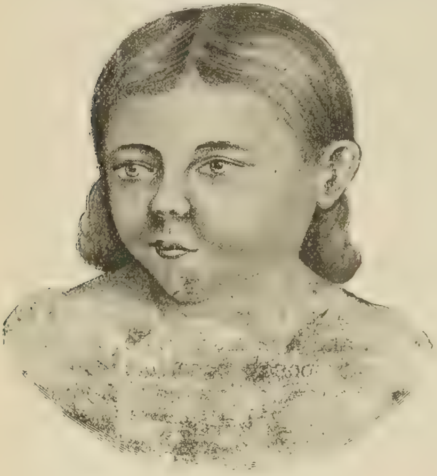


FIG. 388.—OSTEO-SARCOMA OF THE UPPER JAW.

The **General Signs** of a malignant growth of the superior maxilla consist in the appearance of a tumour which, in its earlier stages, may produce various effects, but finally is likely to destroy the bone and occupy the whole of the maxillary region (Fig. 388). It is usually accompanied by nasal obstruction, epiphora, and a discharge of blood or pus from the nares. Severe pain sometimes accompanies the process, especially affecting the second division of the trigeminal. Neighbouring lymphatic glands become enlarged, more especially in the carcinomata; those in the submaxillary region are first involved, and afterwards those in the anterior triangle; secondary deposits in the viscera may also occur somewhat later. The tumour follows a typical malignant course, and, owing to the great vascularity of the parts, its onward progress is very rapid.

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* Sir F. S. Eve, *Brit. Med. Journ.*, June 29, 1907.

The **Diagnosis** of malignant disease of the upper jaw from a simple tumour or cyst should be readily made; the rapidity of its growth, the greater pain and more abundant discharge from the nose, the associated enlargement of the lymphatic glands, and the tendency to spread to and encroach upon surrounding structures, all point to malignant disease. In some cases, however, an exploratory incision is required to make certain of the diagnosis. More frequently the existence of a tumour at all is for some time entirely overlooked, some one prominent symptom, such as neuralgia or epiphora, being treated without ascertaining the cause. Trans-illumination (p. 801) may assist in clearing up the diagnosis, as also radiography, which would indicate the presence of an unerupted tooth in a dentigerous cyst.

Treatment consists in free removal of the growth with a good margin of healthy tissue around it, together with the lymphatic area involved. This not unfrequently involves excision of the superior maxilla, but if the disease has spread beyond the limits of that bone—*e.g.*, into the cheek—or has invaded either primarily or by extension the retro-maxillary tissues, the advisability of attempting removal is very doubtful, since it involves a terrible mutilation, and complete eradication is always a matter of uncertainty. In these cases, as in so many others, early diagnosis is all-important; and inasmuch as this is now practicable, thanks to improving knowledge and experience of intranasal work, the more severe types of operation are less frequently required. Wherever practicable, the alveolus and floor of the orbit ought to be spared, and if the case is recognised sufficiently early, this can often be accomplished.

Lateral Rhinotomy (Moure's operation) is the most effective and satisfactory method of removing growths of the maxilla or neighbouring portions of the nasal cavity which do not encroach on the mouth or orbit. The interior of the nose is treated with cocaine and adrenalin; the patient is then anæsthetized, and the choana plugged. Two incisions are made from the inner end of the eyebrow, one down to the nasal orifice, the other along the infra-orbital border. The triangular flap between these is dissected down and outwards, including, if possible, the periosteum, and the bone is thereby exposed. Incisions are then made through the bones with hammer and chisel as follows: One between the nasal bones, or slightly to one side; a second from the upper end of this horizontally out to the orbital margin; and a third from the lower border of the nasal aperture upwards and outwards to the infra-orbital border close to the infra-orbital foramen. The portion of bone thus marked out, including a small section of the floor of the orbit, can be easily twisted out of its bed by forceps, laying bare the lachrymal sac and canal. The amount of bone removed varies necessarily with the case, but a considerable opening into the antrum and nasal cavity results, and growths of this region can be readily removed, if need be piecemeal, without grave hæmorrhage or serious mutilation. The incisions are subsequently closed by stitches, and the resulting deformity is very slight.

Excision of Superior Maxilla varies somewhat in different cases according to the character and extent of the disease.

The patient's head and shoulders are well raised, and anæsthesia is maintained by means of chloroform given by Junker's apparatus. Preliminary tracheotomy is scarcely necessary or desirable if good assistance is available. The proceeding may be described in stages as follows:

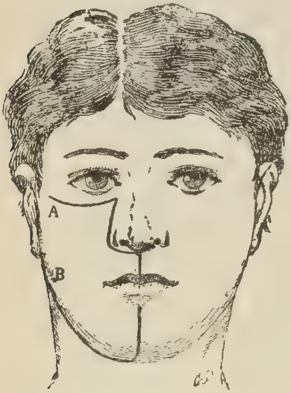

Fig. 389.—A, Incision for Removal of Superior Maxilla; B, for Removal of Lower Jaw.

Stage I.: Incision and Reflection of the Soft Structures of the Cheek.—The central incisor tooth of the affected side having been extracted, the upper lip is divided in the middle line; the incision is carried round the ala and along the side of the nose, to a point half an inch below the inner canthus; it thence extends along the lower orbital margin to a point below its outer border, or even to the zygoma (Fig. 389, A). The flap thus marked out is raised from the bone, and reflected outwards so as to clear the zygomatic eminence, and the more important vessels secured, as they are divided, by Spencer Wells' forceps.

Stage II.: Divison of the Bony Attachments.—The side of the nose is then freed from its bony attachments, and the periosteum stripped up from the floor of the orbit. The nasal process of the superior maxilla is now cut through with a saw (Fig. 390), and also the malar bone divided so as to open into the spheno-maxillary fissure. A keyhole saw is next passed into the nose, and the alveolus and hard palate divided from before backwards through the empty socket of the central incisor tooth. The surgeon then takes a pair of long-handled cutting-pliers, and completes the division of each of these bony attachments. The cutting-pliers must always be applied with the smooth surface towards the tissues which are to be left, and the bevelled surface towards the part which is to be removed. The section of the palate is completed last, and then the cutting-pliers are used as a lever to prise the bone out of its bed, the sound bone acting as a fulcrum, the posterior attachments being thus fractured. The pterygoid processes are broken through close to their origin from the sphenoid, and the lateral mass of the ethmoid yields along the inner orbital margin.

Stage III. : Removal of the Bone and Tumour.—The bone is now seized by lion forceps, one blade holding the alveolus and the other the infra-orbital border; the mouth is gagged open, and the soft palate, if free from disease, is divided from its attachment to the hard by a transverse incision, and when all other connections to the soft tissues have been severed, the bone is removed. Considerable hæmorrhage occurs at this stage from the infra-orbital and posterior palatine vessels; it is checked temporarily by plugging the wound firmly with a sponge, and subsequently the chief vessels are secured by ligature. Any outlying portions of the tumour are now dealt with, and the cavity is packed with strips of sterile gauze. The wound in the cheek is closed, the greatest care being taken to obtain accurate apposition of the flap, especially at the lip margin, and dressed with gauze secured with collodion.

In the majority of cases there is comparatively little shock, and the patients do remarkably well—at any rate, for a time—although, unfortunately, recurrence is only too likely to follow. The plug in the nose is left *in situ* for twenty-four hours and then removed through the mouth, and the wound irrigated with some antiseptic solution. The plug may be replaced, but can usually be dispensed with if the cavity is washed out several times a day. Healing is effected by granulation, and of course a large gap communicating with the mouth remains. This can be subsequently remedied by an obturator, to the upper surface of which is attached a plug or cheek-plate to prevent falling in of the cheek, and to diminish the cavity of the nose. The patient is fed for the first few days by the rectum, or by a tube passed into the pharynx, but soon acquires the knack of swallowing fluids, especially when the soft palate has been left intact. The chief dangers are shock, recurrent hæmorrhage, and septic pneumonia.

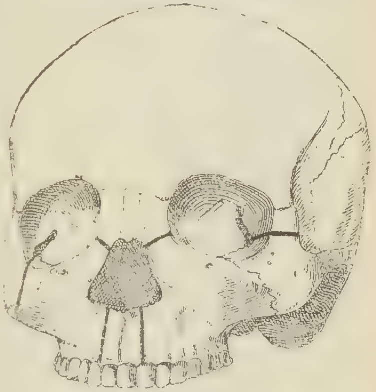

FIG. 390.—SKULL SHOWING LINES OF SECTION OF THE BONE IN EXCISION OF THE SUPERIOR MAXILLA.

On the right side of the skull the malar bone is divided into the spheno-maxillary fissure, as would be required for disease limited to the body of the bone. If the tumour invades the malar bone, incisions as on the left side must be made—viz., horizontally through the upper part of the malar bone into the fissure, and behind through the zygoma.

After the wound has healed to a certain extent, the lymphatic area of the neck should be dealt with as for cancer of the tongue (p. 843).

Tumours of the Lower Jaw.

These are similar in character to those met with in the upper jaw. Thus, **Chondroma, Osteoma, Fibroma,** and the simple and malignant forms of **Epulis,** have been already described.

Dentigerous Cysts form around teeth which are misplaced so that they cannot erupt; though occasionally seen in the upper jaw, they are much more common in the lower. Their characters and nature have been already described under the title of *follicular odontomes* at p. 215. They are met with in young people, and give rise to expansion of the jaw (Fig. 391); the tumour thus formed is at first hard and solid to the touch, but later on eggshell crackling and even true fluctuation are observed when the encasing wall has become thin or absorbed. Absence of one of the permanent teeth may sometimes be noted, but not necessarily, since the corresponding milk tooth is not always shed, owing to the want of pressure from below. Occasionally suppuration within the cavity may be caused by an extension of inflammation from the fang of a neighbouring tooth, or by the cyst being opened during its extraction, and a sinus discharging offensive pus will then form. The *diagnosis* from a myeloid tumour or from a dental cyst is not always easy. The long history and the dental irregularity would point to a dentigerous cyst; whilst dental caries would suggest a dental cyst; but the actual diagnosis is perhaps best made by radiography, when the misplaced tooth can be seen. *Treatment* consists in freely opening the cyst through the mucous membrane, and removing a sufficient portion of the bony wall to permit of the removal of the misplaced tooth. The cavity is left open and allowed to heal by granulation, during which process strict attention to cleanliness must be observed.

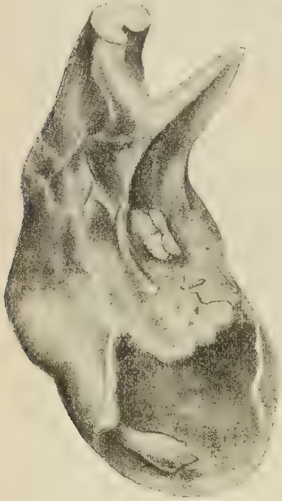

FIG. 391.—DENTIGEROUS CYST, SHOWING EXPANDED CONDITION OF THE LOWER JAW, AND UNERUPTED TOOTH LYING HORIZONTALLY WITHIN IT. (COLLEGE OF SURGEONS' MUSEUM.)

Fibro-cystic Disease of the Jaw (*epithelial odontome*, p. 215) has been already mentioned as characterized by the formation of a tumour, often of great size, which consists of spaces lined with cuboidal epithelium, and supposed to originate from the enamel organ (Fig. 392). It occurs most frequently in young people, and, as a rule, runs a perfectly benign course, although when of large size it may encroach on surrounding parts and even destroy life. The only *Treatment* consists in complete removal of the affected portion of the jaw.

Actinomycosis sometimes develops in connection with the jaws, but more frequently in the lower. It produces a large swelling due to its growth within the bone, which may closely simulate a sarcoma; the constant tendency of this disease to suppurate and discharge the mycelial elements is a characteristic feature. For the general clinical signs and treatment, see p. 192.

Myeloma is met with in the lower jaw, not only in the form of an epulis, but also occasionally as an endosteal growth, usually attacking the central portion of the bone, which becomes expanded by it. It presents but slight evidences of malignancy, and may be treated in the first place by opening the outer shell of bone through the mouth and scraping away the soft contents, the cavity thus formed being swabbed out with pure carbolic acid and plugged with gauze. Should it recur, the affected portion of the bone must be removed, although, whenever possible, a bridge of osseous tissue is left so as to connect the two segments of the jaw; if this is not attended to, they are likely to fall together, and lead to considerable deformity and discomfort. If the whole thickness of the bone is excised, a wire frame or splint should at once be introduced between the fragments with the same object. It is replaced later on by a suitable plate carrying artificial teeth.

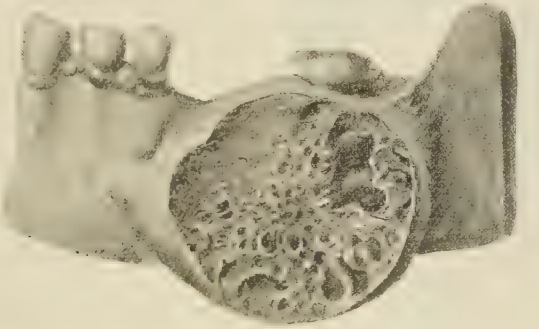

FIG. 392.—FIBRO-CYSTIC DISEASE OF THE LOWER JAW.

(By kind permission of the Council of the Royal College of Surgeons.)

Round or Spindle-Celled Sarcoma also occurs, usually springing from the periosteum, the deeper parts undergoing ossification (Fig. 393). The course is typically malignant, and free removal of the affected portion of the bone must be undertaken.

Epithelioma invades the lower jaw as an extension of a similar affection arising either from the gum, lips, or tongue. Excision of a portion of the bone together with the primary disease is always required, unless it has extended so far as to render extirpation impracticable. Removal of the lymphatic glands of the neck is required at a later date.

Excision of the Lower Jaw is employed in the treatment of various tumours arising from that bone, as also sometimes for extensive necrosis. In the latter case it may be possible to deal with it from the mouth, but when required for the treatment of malignant disease an external incision is absolutely essential.

If the whole of one side is to be removed, an incision is made reaching from just below the red margin of the lip downwards to a point immediately below the symphysis, and thence along the under surface of the body of the jaw as far as the angle; it is then prolonged upwards along the posterior border of the vertical ramus, not extending further than the attachment of the lobule of the ear, so as to avoid the facial nerve (Fig. 389, B). When a large tumour is being dealt with, the whole thickness of the lip should be divided, and the flap thus marked out dissected off the bone, and turned outwards. Where, however, the upper portion of the lip is left, the incisions are carried down to the bone, the facial vessels being secured above and below before division. The soft parts are then freed from the outer aspect of the bone, and the cavity of the mouth opened. The central incisor tooth is drawn, and the jaw divided through the empty socket with a saw and cutting-pliers a little to the side of the middle line By this means the genial tubercles and their attached muscles are not encroached on, or the movements of the tongue impaired. The bone is seized and drawn outwards, and its internal connections as far as the angle divided. It is then firmly depressed, and the muscular attachments of the masseter on the outer side, and of the internal pterygoid on the inner, cut through, as also the inferior dental nerve and artery. By still further depressing the bone, the temporal tendon is exposed, and should be divided by successive touches of the knife, which is kept close to the bone. Finally, the condyle is freed after division of the external pterygoid muscle and

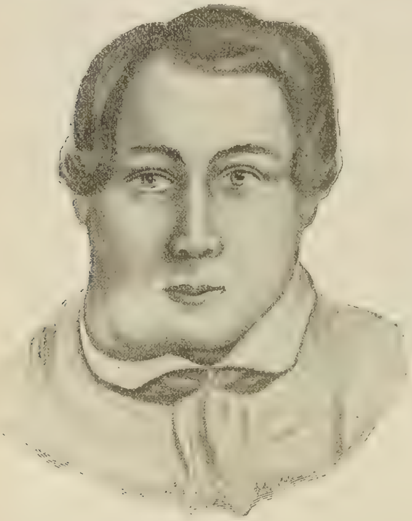

FIG. 393.—OSTEO-SARCOMA OF THE LOWER JAW.

of the ligaments of the temporo-maxillary articulation. The proximity of the internal maxillary artery to the inner aspect of the neck of the bone must be remembered. After hæmorrhage has been arrested, the wound is stitched together and dressed with collodion and gauze; possibly a drainage-tube may be inserted with advantage for a few days through the floor of the mouth. Considerable deformity usually results from this operation, owing to the remaining half of the bone being drawn across the middle line.

Diseases of the Temporo-Maxillary Articulation.

Acute Synovitis may supervene in the course of an attack of rheumatic fever, and is evidenced by pain on movement of the jaw, and by tenderness and swelling immediately beneath the root of the zygoma, due to effusion into and around the joint. Resolution generally follows, but fibroid thickening of the ligaments and impairment of movement may result.

Acute Arthritis arises from pyæmic infection after the exanthemata, or from gonorrhœa, but may be caused by direct extension of inflammation from the middle ear, as in scarlatina. It occurs in children, and is due 'to the persistence of a hiatus in that part of the tympanic plate which forms the floor of the meatus and the roof of the articulation' (Barker). It is characterized by the usual signs of a severe localized inflammation, with the formation of abscesses, and results commonly in ankylosis. Fomentations and the antiseptic opening of abscesses constitute the only early treatment, whilst excision of the condyle is sometimes required at a later date.

Osteo-Arthritis is by no means a rare affection of this joint. It is often symmetrical, and characterized by an enlargement of the condyle, which can be felt distinctly in front of the tragus, especially on opening the mouth, when crepitus is also noticed. The pain is worse at night and in wet weather, and the jaw becomes deflected to the sound side if the disease is unilateral; when both sides are affected, the jaw is pushed forwards, and the chin projects. The articular cartilage undergoes the usual changes, the inter-articular cartilage disappears, and the glenoid cavity becomes enlarged and flattened, so that the eminentia articularis is relatively less marked, thus permitting the external pterygoid muscle to draw the condyle forwards. After a time, considerable difficulty is experienced in opening the mouth, even amounting to ankylosis. Ordinary medical *treatment* may be used in the early stages, but in the later the condyle of the jaw should be excised, a proceeding followed by excellent results.

Tuberculous Disease may arise either in the bone or synovial membrane, perhaps spreading to it from neighbouring lymphatic glands. It runs the usual course of the disease, terminating in caries of the condyle, and ankylosis after protracted suppuration; to prevent this, excision of the condyle is indicated.

Immobility or Closure of the Jaw may be caused by a variety of conditions:

1. True ankylosis of the temporo-maxillary joint, fibrous or osseous, as the result of any of the diseases mentioned above.

2. Cicatricial contraction of the soft structures either within or without the mouth, as from burns, lupus, or extensive operations in the pterygoid region upon the roots of the fifth nerve, from cancrum oris, or very rarely from myositis ossificans.

3. Spasm of the muscles of the jaw (*trismus*), due to reflex irritation, as from carious teeth or an unerupted wisdom-tooth, or some other local lesion. It is occasionally hysterical, and is one of the early symptoms of tetanus.

4. Local inflammatory conditions often render opening of the mouth impossible, both from the pain and swelling—*e.g.*, in mumps, parotid abscess, acute alveolar periostitis—whilst in epithelioma of the jaw, tongue, or fauces, and various forms of tumour, the size and position of the growth may seriously impair the mobility of the jaw.

The term ankylosis can only be applied to the conditions mentioned in the first two groups. In the others appropriate treatment must be instituted according to the character of the affection. Where the closure of the jaw is permanent, it may be due to osseous ankylosis, the bony masses extending not only between the articular surfaces, but also between the alveoli; or to fibrous adhesions within the joint; or to extra-articular contraction of the soft parts, not only the skin and mucous membrane being involved, but also frequently the muscles and deeper structures.

Division of the neck of the bone or excision of the head may thus be impracticable, or, even if possible, is useless, since the muscles of the jaw hold the surfaces in such good apposition as to bring about a recurrence of bony union, unless obviated by implanting a flap of the temporal muscle or a vulcanite plate between the bony surfaces. Division of the intra- or extra-buccal cicatrices is usually unsatisfactory, owing to their rapid re-formation. The best *treatment* in most cases is either removal of the vertical ramus of the jaw down to the level of the alveolus, or the plan suggested by Esmarch, viz., excision of a wedge of bone, with its apex towards the alveolar border, from the neighbourhood of the angle, and the establishment of an artificial joint at that spot. The incision should be made below and behind the angle down to the bone, from which the periosteum is stripped up, and division is accomplished by means of the saw.

Excision of the Condyle of the Jaw is not always a simple operation, since the space at the surgeon's disposal is limited by the zygoma above, the facial nerve below, the parotid gland in front, and the external ear behind. The best incision is a curvilinear one, commencing over the middle of the zygoma, and passing downwards in front of the tragus. It should merely divide the skin and subcutaneous tissue, and the flap thus marked out is turned forwards.

A transverse incision is now made through the deep fascia immediately below the posterior extremity of the zygoma, extending down to the neck of the bone, which is cleared by a raspatory and divided by cutting-pliers; the condyle is then grasped by necrosis forceps, and twisted out. But little bleeding occurs, and the wound heals by first intention, except along the track of the drainage-tube, which should always be employed.

Internal Derangement of the temporo-maxillary joint (locking or clicking jaw) is not a very uncommon affection, resulting from laxity of the interarticular cartilage, which gets folded up and caught between the condyle and the eminentia articularis when the mouth is opened. The effect is a temporary painful fixation or locking of the jaw, which is usually set free by lateral movements. At other times there is marked clicking or creaking of the jaw when the mouth is opened. In bad cases *treatment* consists in excising or stitching down the loose cartilage—preferably the former—through an incision made as for excision; in the milder cases nothing can be done except to assist the removal by blistering of the synovial effusion which may be present.

CHAPTER XXIX.

AFFECTIONS OF THE NOSE AND NASO-PHARYNX.

Depression or Flattening of the Bridge of the Nose is either a result of traumatism, such as a fracture of the nasal bones (p. 493), or may follow defective growth of the ethmo-vomerine septum, due to disease either of syphilitic or tuberculous origin early in life, whilst it may also be due to tertiary syphilis. If caused by injury, and dealt with promptly, it may be remedied; but when once acquired, and especially if the consequence of disease, treatment is much less satisfactory. Several cases have been recorded, however, in which bone-grafting has been successful. An incision is made down the middle line of the nose, the soft parts are reflected on either side, and, after making a comfortable bed for it, the bone-graft is introduced, and kept in position partly by sutures, but mainly by closing up the wound in the soft tissues. In one case the patient's own fourth metatarsal bone was utilized with success, whilst platinum, gold, or celluloid frames have also been employed in the same way.

The subcutaneous *injection of paraffin* has been utilized in many of the worst cases with advantage. At first a paraffin was employed which melts at 110° F.; this, however, caused a good deal of irritation, and its exact limitation to the desired area was difficult. At the present time a cold paraffin is utilized, being expressed little by little from a powerful syringe (Mahu's), and the tissues are built up into shape exactly as is desired. The paraffin is supposed to remain permanently as an infiltration of the tissues, but further experience is required to make sure that this is the case.

Expansion of the Bridge of the Nose is always the outcome of some long-continued intranasal pressure, especially from the growth of polypi. It rarely follows the development of mucous polypi, except when they are very large and chronic, but it is not an uncommon accompaniment of the fibrous or fibro-sarcomatous variety. The bridge is flattened and bulged out on either side, giving the face an appearance justifying the name ' frog-nose ' which has been applied to it.

Congenital swellings at the root of the nose are not very uncommon, and may be either a meningocele (p. 725), or a dermoid cyst which may have a deep connection between the nasal bones with the cerebral membranes. It is often advisable to leave them alone until adult life, since their intracranial connections may be shut off as the child grows up.

It is impossible to discuss all the different affections of the **skin of the nose.** Many of them are associated with the sebaceous glands, which in this region are very large and abundant. Thus, *acne* is commonly met with, arising from an inflammation of the glands after obstruction to their ducts. It is especially frequent in drinkers and dyspeptics, women addicted to tea-drinking often suffering severely. When the superficial capillaries become markedly dilated and the face readily flushes on the imbibition of hot or stimulating fluids, the term *rosacea* is attached to it, whilst if acne pustules are also present, it is known as *acne rosacea*. Sometimes the spots become much enlarged, and there is a considerable amount of infiltration of the base, a condition described as *acne hypertrophicum.* In the most exaggerated stage the sebaceous glands become overgrown and form large protuberant nodular masses projecting from the end of the nose, and covered with red greasy skin, in which the dilated orifices of the glands are very evident, and with dilated capillaries coursing freely over them. This condition is generally known as *lipoma nasi, rhinophyma,* or *hammer-nose* (Fig. 394). The **Treatment** of simple acne consists in correcting the dyspepsia, and limiting the amount of, or interdicting entirely, alcohol or tea. Capsules of ichthyol (3 to 10 minims) may also be administered thrice daily, and soothing applications should be used locally, such as a lotion consisting of calamine, oxide of zinc, and precipitated sulphur, held in suspension with glycerine and lime water. Dilated and unsightly capillaries may be dealt with by puncturing them with the galvano-cautery or an electrolytic needle. Rhinophyma requires operative proceedings; the protuberant mass should be freely dissected away from the cartilages, and the raw surface covered by Thiersch grafts or allowed to granulate.

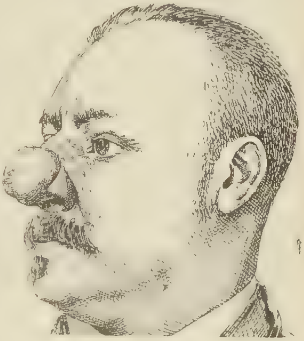

FIG. 394. — RHINOPHYMA, OR HAMMER-NOSE.

Partial or Total Destruction of the Nose may result from traumatism, but usually from some chronic inflammatory or malignant growth, such as lupus, tertiary syphilis, or rodent ulcer. Epithelioma sometimes attacks it, and requires total removal of the nose for its cure. In any of these conditions the resulting deformity is so repulsive that the surgeon is certain to be asked to undertake some proceeding to remedy it. Indian surgeons have had a good deal of experience in this direction, since in that country cutting off the nose is often resorted to as a means of avenging some real or fancied wrong. Various plastic operations have been devised, which, however, we can only indicate briefly here, referring students to larger works of operative surgery for fuller details.

The chief methods of **Rhinoplasty** are as follows:

1. The so-called *Indian method* * consists in the formation of a nose from a flap of skin obtained from the forehead. The flap (Fig. 395) is more or less pyriform, with the pedicle so placed as to contain one of the frontal arteries and the supratrochlear nerve. Necessarily its exact shape and size vary with the character of the defect and with the type of nose desired. Keegan, who has done some excellent work in this direction, advises that the skin covering the nasal bones, as high as the level where the bridge of spectacles would rest, should first be turned down in two flaps, using their attachment to the nasal mucosa as a hinge, so that the cutaneous surface shall look inwards and the raw surface outwards. Over these the forehead flap is placed, and there should be sufficient tissue in the nasal flaps to enable their free ends to be stitched below to the forehead flap on either side of the columna, thus completing the anterior nares. The columna itself is formed by the free end of the forehead flap. Drainage-tubes are inserted through the anterior nares and kept in position for ten to fourteen days. The lateral margins of the flap are carefully sutured to the freshened edges of the defect. When the union of the lower portion is sufficiently firm, the nose is made more shapely by partially dividing the twisted pedicle, but if possible the integrity of the frontal artery should still be retained. The wound in the forehead is drawn together as far as possible by sutures, and healing promoted later by skin-grafting.

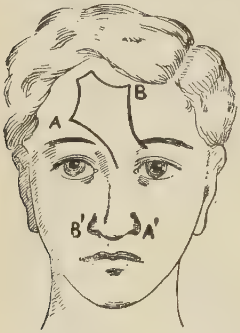

FIG. 395.—INDIAN METHOD OF RHINOPLASTY, SHOWING THE SHAPE AND POSITION OF THE FOREHEAD FLAP.

The points A and B are brought down to A′ and B′ when the flap is twisted into position.

2. In the *Tagliacozzian or Italian operation* (so called from Tagliacozzi, the surgeon who first proposed it) a flap of skin is taken from the arm. The pedicle must always be broad, and is left attached to the upper part of the inner aspect of the arm; it must be so placed that it can be brought into apposition with the nasal defect without tension, the fore-arm and hand being fixed by a suitable apparatus above the head, and retained there until good union has been accomplished, when the pedicle is gradually divided. Absolute fixation of the arm is an essential, and as this may need to be maintained for two or three weeks, the patient needs a considerable amount of pluck and perseverance. When the pedicle has been detached, subsequent plastic measures are required to mould the new tissue to the shape of the nose.

3. The cheeks have also been made use of in what is known as the *French method* to supply material for the nose, flaps being dissected up from either side, and united in the middle line.

4. The above operations have the great objection that the new nose only consists of soft tissues, and hence it is very likely to shrivel up and contract, so that all that is finally obtained is a covering for the defect, which is often quite flush with the surface. To obviate this, and to secure a bony basis for the

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* For full details of this plan we would refer to Keegan's 'Rhinoplastic Operations.' Baillière, Tindall and Cox, 1900.

nose, attempts have been made to utilize a finger for the purpose, and Mr. Astley Bloxam has had one or more successful cases. The terminal phalanx is removed, the soft parts split down the middle line on the palmar aspect, and the divided segments united by suture to the margins of the nasal defect. When union is secured, the amputation of the finger is completed.

Naturally, where only a portion of the nose is destroyed, partial operations can be devised to meet the requirements of the case.

It must be admitted, however, that the nose produced artificially by any of these methods is rarely satisfactory, and has a considerable tendency to shrink. Indeed, it is probable that in the majority of cases patients are better off with an artificial nose made of vulcanite or some such material and suitably coloured, and held on by a spectacle frame or some adhesive substance.

Examination of the Nasal Fossæ and Naso-Pharynx.—In order to understand fully the diseases of the nose, it is essential that the interior of the organ be efficiently examined, and to do this three chief methods are employed.

1. *Anterior rhinoscopy* consists in the illumination of the front of the nasal cavity through the anterior nares. A good light is required, such as that derived from an electric head-lamp, and some form of nasal speculum. Perhaps Thudichum's speculum is one of the best; it consists of two unfenestrated blades, connected by a U-shaped spring, which is held in the hand, whilst the blades are inserted into the nostril, the nasal vibrissæ being thus held aside; the ring and index fingers are placed one on each limb, so as to regulate the amount of tension, and prevent painful overstretching. By this or similar means one is enabled to see the anterior part of the nasal fossæ, including the inferior turbinal and the erectile tissue at its anterior extremity. The amount of distension of the latter limits the view of other structures; if greatly swollen, it feels soft and even fluctuating, but collapses entirely on the application of a 5 per cent. solution of cocaine, allowing the free convex border of the middle turbinal to come into view, as also the cleft or olfactory fissure between it and the septum. The septum can also be examined, frequently showing deviations from the middle line, and thickenings or spurs of bone or cartilage, which run in an antero-posterior or vertical direction. A certain amount of erectile tissue is also present on the septum.

The introduction of a sterilized probe under the guidance of the eye is of the greatest value in examining the nose. It not only serves to distinguish the different qualities of growth that can be seen, but will also give information concerning regions beyond the surgeon's eye.

2. By *posterior rhinoscopy* is meant an examination of the posterior nares by a mirror placed behind the uvula and soft palate. It is by no means easy to accomplish, and requires some dexterity and practice. The tongue should be depressed, and a small mirror, previously warmed to prevent condensation of moisture, is then passed behind the uvula, without touching it or the posterior wall of the pharynx, and by shifting its angle and position a view should be obtained of the structures exposed posteriorly. If not successful, and it is absolutely necessary to obtain a view, the fauces should be cocainized and the velum held up by some form of palate retractor, such as White's. The posterior nares (or choanæ) are seen, separated by the vertical posterior free margin of the septum, and within each cavity the rounded ends of the turbinals with the meatuses intervening. The inferior meatus often looks very small owing to the prominence of the velum palati, whilst the middle meatus may be encroached on by tumefaction of the erectile tissue at the back of the inferior spongy bone. Outside the choanæ are seen the yellowish openings of the Eustachian tubes, and above and between them Luschka's tonsil, a raised collection of lymphoid tissue in the roof of the pharynx is occasionally observed.

3. *Palpation of the Posterior Nares* with the index finger, previously dis-

infected, will, however, give better results in the majority of cases to those who are not specially practised in the above method. The index finger is passed behind the uvula and velum, and the nares can then be well explored, and the existence of adenoids or other growths determined.

Spurs and Deviations of the Nasal Septum.—By the term *spur* is meant a cartilaginous or bony ridge or thickening of the septum, which runs in a more or less transverse direction, and is of congenital origin. A *deviation* is a bending of the septum from the middle line, leading to inequality of the nasal fossæ; the cartilaginous septum is mainly involved, and the condition is sometimes of traumatic origin. The two conditions are not unfrequently combined, and when they are not the outcome of an injury, a high-arched palate is usually present. They give rise to unilateral nasal obstruction, associated with a chronic rhinitis on the patulous side. Attacks of paroxysmal sneezing of the hay-fever type, and possibly asthma, may result from these defects. External deformity in the shape of nasal asymmetry is visible in most of the cases of deviated septum. Spurs may be removed by a special knife or spokeshave, if cartilaginous, and by a suitable saw—*e.g.*, Bosworth's—if bony. Most of these operations, however, have been displaced by *submucous resection* of the septum. It is performed under a local or general anæsthetic, and the results are excellent. The mucous membrane is stripped up on the convex side, and the whole thickness of the cartilage removed; the two layers of mucous membrane are placed in contact, and by their union constitute a median septum.

Foreign Bodies are rarely impacted in the nasal passages except in children, in whom the condition is not uncommon. Any unilateral purulent discharge from a child's nose should suggest the likelihood of such an occurrence, peas, beads, or buttons being the substances usually introduced. A certain amount of unilateral obstruction to nasal respiration is caused thereby, followed by a catarrhal or even suppurative rhinitis, and in old-standing cases a rhinolith or nasal calculus may be caused by the deposit of inspissated mucus upon the outer surface of a foreign body. Removal is best effected by thoroughly cocainizing the affected side so as to reduce the congestion and swelling of the mucous membrane, and then seizing the foreign body by suitable forceps, a hook, or a snare. This should never be attempted without the assistance of frontal illumination and a rhinoscope. Necessarily, all instruments used for this purpose should be thoroughly sterilized. After the removal, the nostrils are carefully washed out for a few days with a weak alkaline antiseptic lotion, such as salt and water to which a little sanitas has been added. The old-fashioned plan of attempting removal by syringing is most unsatisfactory, and, indeed, dangerous, and should be totally discarded.

Acute Rhinitis.—Several distinct varieties of this affection are described.

1. The **Catarrhal** form is extremely common, constituting what is popularly known as a 'cold in the head.' It is not only due to ex-

posure to cold, but may be caused by irritating gases, dust, and the pollen of plants (hay-fever). Not only is the nasal mucosa involved, but the inflammation often extends to the frontal or maxillary sinuses, causing brow-ache and face-ache, whilst if it spreads to the mucous lining of the Eustachian tube, temporary deafness may ensue. In infants great dyspnœa often results owing to the extreme narrowness of the nasal passages, and this may be so marked as to interfere for a time with breast-feeding. Apart from the usual domestic remedies directed to increasing the action of the bowels, kidneys, and skin, considerable relief can often be obtained by washing out the nasal cavities three or four times a day with a weak warm alkaline lotion containing borax, or by spraying the interior of the nose with menthol dissolved in paroleine by means of a suitable atomizer.

2. A **Suppurative** form arises not unfrequently as a result of acute suppuration in one of the accessory sinuses (acute empyema), and then treatment must be directed mainly to the sinus. Occasionally it is due to gonorrhœal infection either in adults or infants, but perhaps more commonly in the latter. The discharge is abundant, and causes much obstruction to nasal respiration, whilst ulceration is likely to occur. The passages must be well cleansed with a solution of boric acid several times daily, and the interior sprayed or painted with a weak solution of nitrate of silver (gr. 5 to 1 ounce) once every day as long as the suppuration continues.

3. True diphtheria also occurs in the nasal fossæ, usually as a complication of the same disease elsewhere, and requiring a similar form of treatment (p. 134).

Chronic Rhinitis occurs in many distinct types, of which we can merely give a bare outline.

1. **Chronic Hypertrophic Rhinitis,** one of the most common forms, is characterized by engorgement of the erectile tissue covering the inferior turbinated bone, causing obstruction to nasal respiration and an abundant discharge of muco-pus. It usually occurs in patients with prominent noses, where the passages are narrow, and may be lighted up by some slight local irritant, such as a sudden change of temperature. The anterior end of the inferior turbinal is swollen, red, and rounded, the mucous covering being œdematous, and the mass feeling, on touching it with a probe, like a sac full of fluid. The local application of a 5 per cent. solution of cocaine causes its complete, though temporary, collapse in a few moments. If it is allowed to persist, hypertrophy of the mucous membrane follows, and in the most marked types a projecting papillomatous-like mass, almost resembling a polypus, results. It is, however, merely an inflammatory hyperplasia, and not a new growth; true papillomata are extremely rare in this situation. The posterior end of the bone may be similarly affected, and the mucous covering of the middle turbinal may participate in the same process. A certain amount of pharyngitis or laryngo-tracheitis may also be present. *Treatment.*—In the early stages all that is

required is to wash out the nasal cavity night and morning with some simple nose lotion, such as borax or bicarbonate of soda (5 grains to 1 ounce). This may be accomplished either by sniffing the solution from the palm of the hand, or by using some form of nasal irrigator or douche; Basdon's douche is perhaps the best for this purpose. If such is insufficient to give relief, or if collapse is not produced by cocaine, the surface may be swabbed over with some diluted caustic (*e.g.*, chromic acid, 5 grains to 1 ounce), or, better still, a point of galvano-cautery at a red heat may be run along the length of the bone. In the later stages removal of the hypertrophied excrescences by the cold-wire snare, or by the galvano-écraseur, is required.

2. **Chronic Rhinitis Sicca** is associated with collapse of the erectile tissue, and there is but little discharge, since the exudation dries within the nasal cavities and forms inspissated crusts or scabs which are often difficult to remove. The nasal fossæ are in this case more patulous than usual, and a dry pharyngitis and chronic laryngitis are often present. Both nostrils may be involved, but occasionally the affection results from deviations of, or spurs on, the septum, and then is unilateral, the discharge coming from that side which is most patulous, whilst the narrowed side remains healthy. When symmetrical, the disease is rather due to constitutional than to local causes, occurring in weakly, anæmic women, and is to be treated by general rather than local measures. In the unilateral form, the deviation or spur must be remedied. In this way the inspired air is made to pass more freely along the narrowed healthy side, and the other nostril is dealt with by the use of weak alkaline lotions. It may also be advisable to plug the dilated side with cotton-wool for some time daily, so as to enforce respiration through the other nostril. Treatment is always likely to be prolonged, and it is possible that a daily alkaline nose lotion may be needed permanently. Stimulating applications are never borne well, and hence should rarely be ordered.

3. **Chronic Atrophic Rhinitis** (**Ozæna**) is characterized by an exceedingly offensive muco-purulent discharge from the nostrils. It must be carefully distinguished from such conditions as tuberculous or syphilitic disease of the turbinated bones or of the septum, suppuration in the accessory sinuses, the impaction of foreign bodies, or the ulceration of malignant growths, in which an offensive discharge also occurs.

True ozæna is usually met with in young females, and may sometimes originate from traumatism, or after one of the exanthemata. The nose is almost always wide and roomy; the lips are often thick and everted, and the mouth is usually held open owing to the impediment to nasal respiration caused by inspissated mucus. The fœtor of the breath due to the decomposition of this discharge is the special feature that calls attention to the complaint; it is peculiarly searching and objectionable, but the patient fortunately is not cognizant of it. There is not much discharge, but at varying periods large crusts come away, giving relief both to the nasal respiration and to the fœtor. Both nostrils are usually involved. The disease lasts for many years, but in time tends to improve, and gradually to disappear.

On examination, the nares are found to be unusually patulous, and the vibrissæ are scanty. The mucous membrane over the turbinated bones is dry, collapsed, and pale, so that after clearing away all the dried mucus and scabs, it is often possible to see the posterior pharyngeal wall, and even the orifices of the Eustachian tubes. The pharyngeal wall is also dry, and may be coated with a film of inspissated mucus. No ulceration is present, although the removal of the crusts may be associated with a slight amount of bleeding owing to their close attachment to the mucous membrane. The examination of a case of suspected ozæna should also include the accessory cavities of the nose, since many cases in which crust-formation is a prominent symptom are really due to an empyema of one or more of the sinuses.

Treatment.—The first essential is to keep the nose clean and free from putrefying masses of dried secretion. This must be accomplished by irrigating the cavity once or twice daily with a warm weak solution of common salt to which a little sanitas has been added. At first it is well for the surgeon to see to this himself, but after a while the patient or her friends can be entrusted with the task. Every portion of scab ought to be removed daily, and the surface lubricated with some such application as a spray of menthol and paroleine (10 grains to 1 ounce). The nose should then be partially plugged with a tampon of cotton-wool, especially along the lower meatus, and if thought desirable the wool may be medicated with some antiseptic. By this means a flow of mucus from the membrane is determined, and the discharge is thus rendered more fluid, and inspissation prevented. A similar end may also be obtained by plugging the nostril partially with a rubber tube, so as to diminish its size. The general health must be attended to, and patience and perseverance will generally be crowned with success. Operative measures are scarcely ever required in this disease, although they have frequently been resorted to most unnecessarily.

Disease of the Accessory Sinuses of the Nose is a frequent accompaniment of either the acute or chronic nasal affections just passed under review, or it may arise from more localized lesions—*e.g.*, antral trouble from affections of the teeth, or frontal sinus mischief from traumatism. Perhaps the most common cause is a sharp influenzal attack, which may lead to an involvement of the nasal fossæ and all the sinuses (the so-called pan-sinusitis); this is tolerably amenable to treatment in the early stages, but if neglected, may become chronic, and then serious trouble may result. Pyogenic infection of the nasal fossæ from the introduction of dirty instruments by careless or meddlesome surgeons may also be responsible for this condition. The obvious outcome is the persistent discharge of offensive purulent material from the nose, which is often wrongly termed ozæna; to this may be added special features according to the particular sinuses which are mainly affected.

It must be remembered that the outlet of most of the sinuses (Fig. 396) is badly placed for drainage purposes, especially the maxillary antrum, the opening to which is near the roof rather than the floor. Even in the case of the frontal sinus, the outlet, which is well situated for drainage, is a long narrow passage easily blocked by œdematous swelling of the mucous lining. When once suppuration has commenced among the sinuses, it is likely to spread from one to another owing to the close proximity of the various orifices; thus, pus escaping from the infundibulum is almost certain to find its way into the antrum or ethmoidal sinuses, especially if the escape of the discharge is hindered by the presence of granulation tissue.

In the more *acute* cases which follow influenza or cold, the antrum and frontal sinus are most frequently involved. Readers are referred back to what has already been written on these subjects (pp. 742 and 801), with the emphatic reminder that careful treatment during the early stages may prevent the affection becoming chronic and save the patient from much suffering and danger. The nose should be carefully irrigated with warm saline solution night and morning, and the antrum washed out after puncturing its inner wall.

In *chronic* cases the discharge will be found to come from one or both sides of the nose, and the patient will complain of feeling stuffed up; breathing will be mainly oral, and the breath is likely to become offensive. On examining the interior of the nose, even after cleansing it, the cavity is not found to be patent as in ozæna, but is blocked up with polypoid masses of granulation tissue, which project mainly from the middle meatus; they are often covered with a half-dried scab, and pus can be seen to exude from it when pressed upon; this usually comes from the antrum or frontal sinus, a mass of granulation tissue developing both above and below the entrance. A probe passed into the mass always impinges on dead or carious bone, which is probably a part of the middle turbinal.

The special features of diseases of the frontal sinus and antrum of Highmore have been already indicated, and their peculiar dangers and methods of treatment discussed.

The **ethmoidal** cells lie along the inner wall of the orbit, and should they become distended with mucus or pus, may bulge into the orbital cavity on the inner side and even displace the eyeball outwards. The **sphenoidal** sinus lies at the back of the nose (Fig. 396, S), and the discharge escapes downwards into the nasopharynx. Suppuration therein causes deep-seated pain in the back of the orbit and nose, and, unless relieved, may determine infective complications about the base of the skull—*e.g.*, basal meningitis, thrombosis of the cavernous sinus, or affections of the nerves to the eye and orbit in the neighbourhood of the sphenoidal fissure.

Treatment, except in the simpler cases, should always be handed over to a rhinological expert, as operative measures of a serious character may have to be undertaken. The essential element is drainage of the affected cavities, together with removal of the protuberant granulation tissue and diseased bone which hinder the exit of the discharge. It may be desirable for a few days to treat the patient merely by irrigation of the nasal fossæ, and of such sinuses as are readily accessible, *e.g.*, the antrum and frontal sinus; but further and more effective treatment must not be long delayed. In many cases the lining membranes of these cavities will be thickened and transformed into polypoid masses, and hence the more extensive of the procedures mentioned at pp. 743 and 813 are likely to be required for the frontal sinus and antrum. For suppuration of the ethmoidal sinuses it may suffice to remove the anterior portion of the middle turbinal and to break down the inner wall of the cells, so as to lay the cavities into the nose; but when the surrounding bone has become diseased, it may be desirable to open into them from the orbit by prolonging backwards the incision for exposing the frontal sinus. The sphenoidal sinus can, of course, only be dealt with from its nasal aspect, and an opening has to be carefully made into its anterior wall, which is picked away by punch forceps.

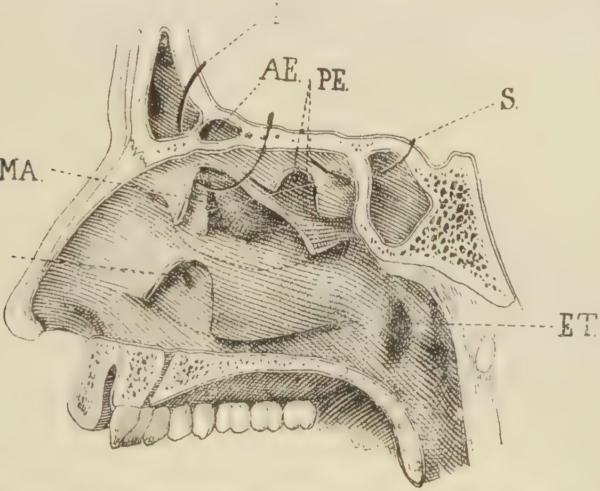

Fig. 396.—Outer Wall of Nasal Fossa, indicating the Position of the Accessory Sinuses and of their Orifices.

F, Probe passed from frontal sinus down the infundibulum to middle meatus; AE, anterior ethmoidal cells; PE, orifices of posterior ethmoidal in superior meatus, shown by removal of a portion of the superior turbinal; S, sphenoidal sinus with probe in its orifice; MA, orifice of maxillary antrum shown by cutting away part of the middle turbinal; ND, orifice of nasal duct under cover of the inferior turbinal, part of which has been removed; ET, pharyngeal opening of Eustachian tube.

Syphilitic Disease of the nasal fossæ is generally tertiary in type, and consists in a diffuse gummatous affection of the septum and turbinals, with resultant suppuration, and either caries or necrosis. The condition is usually a very offensive one, but the accessory sinuses are not specially liable to involvement. *Treatment* is of the usual antisyphilitic type, including the injection of salvarsan, and perhaps the use of iodides and mercury. Locally, the nose must be kept clean by irrigation, and diseased bone removed. It is probable that if the septum is seriously affected, the bridge of the nose will become depressed.

Nasal Polypi.—Two forms of nasal polypus are described, viz., the simple or mucous polyp, and the fibrous or fibro-sarcomatous. Other malignant tumours occur in the nasal fossæ, to which, however, the term polypus can scarcely be extended; they mainly originate from the superior maxilla.

The **Mucous Polypus** consists of a soft gelatinous mass, which on microscopic examination much resembles myxomatous tissue, covered by ciliated columnar epithelium, and supplied freely with bloodvessels. Polypi are inflammatory in origin, consisting merely of œdematous hypertrophic tissue, mainly dependent on a chronic osteitis of the underlying turbinated bone. They are often associated with suppuration of the adjacent sinuses, especially the ethmoidal, but the pus production may be secondary and not causative. Polypi are usually situated on the middle and superior turbinals; they rarely start from the roof of the nasal fossæ, occasionally in the sinuses, or at the orifices leading into them; they hardly ever involve the septum or inferior turbinal. Polypi are generally multiple (Fig. 397), a large one projecting downwards and forwards towards the anterior nares, and covering or hiding a series of smaller ones, which readily spring into prominence when that in front is removed. They are usually attached by a small pedicle, and when developing in the nasal fossa are pyriform and laterally compressed. When of large size, they may protrude through the nostrils, and then the epithelium covering the anterior portion becomes squamous, and the mass firmer in texture and papillomatous in appearance. Sometimes they project backwards into the pharynx, and are more distinctly globular and usually single.

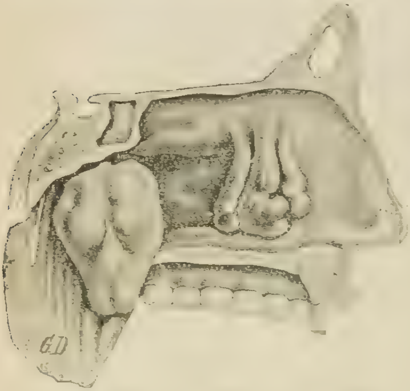

FIG. 397.—MUCOUS POLYPI OF NOSE, SPRINGING FROM THE BACK AND FRONT OF THE MIDDLE TURBINATED BONE.

The main **Symptom** arising from nasal polypi is obstruction to the passage of air along one or both sides of the nose. This is always of gradual onset, and invariably worse in wet weather, on account of the hygroscopic property of mucoid tissue. There is often a thin, watery discharge from the nose, which may perhaps be blood-stained. The patient is unable to blow the nose, and his articulation becomes nasal in quality. On rhinoscopic examination one finds a grayish semi-translucent glistening mass occupying the nostril, and attempts to blow the nose render this more obvious. Its pedunculated nature can be easily demonstrated by passing a probe around it. When of large size, some flattening or expansion of the bridge of the nose may be caused thereby, and possibly epiphora from pressure on the opening of the nasal duct.

The **Diagnosis** should present no difficulty to one who knows how to employ the nasal speculum. Abscess, a spur, or a deviation of the septum, though causing unilateral obstruction, can be recognised by the exercise of a very small amount of intelligence. Œdematous masses of granulation tissue, associated with tuberculous or syphilitic disease of the bones, are recognised by involving usually the septum as well as the turbinals, by the absence of superficial epithelium, and by not being distinctly pedunculated; carious bone can often be felt by a probe through the granulation tissue. From hypertrophy of the mucous membrane over the inferior turbinated bone, a polypus is known by the fact that it scarcely ever springs from this region, whilst the former condition is sessile and red, and shrinks considerably on the application of cocaine.

The **Treatment** of mucous polypi consists in their removal either by the snare or the curette.

The *snare* is specially indicated if there is a single polypus hanging down the naso-pharynx, or if the polypi are few in number. The patient is seated in a chair, and the surgeon sits or stands in front of him. The nasal cavities are well sprayed with a solution of eucaine or cocaine (5 per cent.) and adrenalin (5 per cent.), and the situation of the pedicle ascertained by inspection and by the use of a probe. The snare is then introduced, and the loop passed round the base of the pedicle and gradually tightened until it has cut through. The same process is repeated to the smaller tumours until the nostril is clear. A certain amount of hæmorrhage may result, and to check this the nostrils should be plugged with a strip of sterilized gauze, but this should never be left unchanged longer than twenty-four hours. The plug is then removed, and the base of the growth carefully examined and cauterized with the galvano-cautery by the aid of a nasal speculum so as to prevent recurrence. The patient should be again examined after a short interval, so that any smaller polypi which have commenced to develop may be suitably treated.

Where many polypi exist, or if recurrence has occurred after the removal by the snare, the nostril must be effectively curetted, and the polypi and underlying bone removed as a stage in the operation for the cure of the underlying sinus trouble.

A **Fibrous Polypus** is the term applied to a fibroma, which sooner or later becomes sarcomatous, springing from the base of the skull, especially from the basi-sphenoid or basi-occipital. It is at first distinctly pedunculated, and is usually firm, smooth, and fleshy in character; when of large size, it may be lobulated. The early symptoms are almost limited to those of obstruction to nasal respiration, but to this is not unfrequently added severe epistaxis, owing to the vascularity of the capsule and of the overlying mucous membrane. As it increases in size, ulceration occurs, leading to a fœtid sanious discharge, and the growth rarely remains limited to the nasal fossæ. If pushing forwards, it may lead to expansion of the bridge of the nose and separation of the eyes, which may even be made to diverge; but if backwards, it may depress the velum, and hang downwards as a naso-pharyngeal tumour. In other cases it may force its way into the orbit or any of the other surrounding cavities, or may even erode the base of the skull, or encroach upon the cranium. It is rare for any of these latter manifestations to occur until after the tumour has taken on a distinctly sarcomatous type.

The disease usually attacks young people, and mainly those in the second decade of life. It progresses with considerable rapidity, and the fatal issue may be due to hæmorrhage, asphyxia, or cerebral complications.

Treatment.—When the growth is small and polypoid, it can sometimes be dealt with from the anterior nares by means of a galvano-écraseur. The wire loop is inserted from the front, and hitched over the tumour, so as to encircle its base, by the assistance of the right index finger passed behind the velum. The pedicle must be divided as near the skull as possible, and even then recurrence is almost certain to follow. Nélaton's operation, or one of the other methods described below (p. 827), will in some instances assist the surgeon to reach the base of the skull and deal with the tumour. In the more severe cases, where the growth has become diffuse, it is very doubtful whether much good can be done by operation, since the base of the skull is sure to be gravely affected.

Other forms of **Malignant Disease of the Nose** are met with, and may originate in any part of the nasal fossæ. **Squamous epithelioma** is that which occurs most frequently; the symptoms consist in the presence of a blood-stained discharge, and a certain amount of respiratory obstruction, together with pain and cachexia. The lymphatic glands at the angle of the jaw are early enlarged, and the course of the disease is usually rapid, owing to the great vascularity of the part. It is sometimes possible to deal with these patients by operative measures, which must be varied according to the requirements of the case. Radium may perhaps be of service.

Sarcoma may also commence in the nose itself, quite apart from that which originates in the superior maxilla. It gives rise to the usual signs of an intranasal growth, and may occasionally be dealt with in a satisfactory manner by local means, such as curetting and the application of caustics. Not a few cases are on record in which such treatment has proved efficacious in curing the disease, although one would now raise the question as to whether these tumours were sarcomatous at all, and not endotheliomata.

The **operations** which have been devised *for dealing with disease of the nose and naso-pharynx* are so numerous and complicated that it is impossible for us to mention more than a few of the most useful and important.

(*a*) In many cases of intranasal disease considerable assistance can be derived by *opening up the anterior nares*, especially when one is operating for caries or necrosis of the turbinated bones. It may suffice merely to divide one ala nasi and the attachments of the cartilages to the maxilla; but where both sides are involved *Rouge's operation* is advisable. This consists in the detachment of the mask of the face from the maxilla by everting the upper lip and incising the mucous membrane and subjacent tissues until the nasal cavities are opened. The septum nasi is divided by cutting-pliers, and the nasal cartilages are completely separated. The soft tissues of the face can then be retracted upwards, and the nasal fossæ fully exposed. The bleeding is always considerable, and the space gained in children is but slight. When the operation is completed, the mask of the face is allowed to fall back again into position, union occurring without difficulty, although no sutures are employed.

When the upper and anterior portion of the nasal cavity is to be dealt with, *lateral rhinotomy*, as described above (p. 805), or some modification of it, may be employed with advantage.

When the septum alone is involved in malignant disease, it is possible to deal with it by an operation, which consists in splitting the upper lip in the middle line, and carrying the incision round the ala nasi on each side so that the lower portion of the nose can be turned upwards after dividing the septum. A wedge-shaped portion is then removed from the front of the palate after detaching the muco-periosteum from its buccal aspect. An excellent approach is thus obtained into the nasal cavity, and the entire septum can in this way be removed without difficulty. The parts can be afterwards brought together quite naturally, and the deformity is very slight. A patient on whom this operation was performed for undoubted epithelioma of the septum reported himself at hospital eight years later; he was quite free from recurrence, and apart from a sunken bridge to his nose, there was no deformity.

(*b*) When the disease is located further back, originating rather in the naso-pharynx than in the nose itself, the *palatine route* may be used with advantage. Perhaps the best of the several suggested operations is that of *Nélaton*. This consists in a median section of the velum and of the mucous membrane covering the posterior half of the hard palate. A transverse incision is then made on either side of the anterior extremity of this, and two muco-periosteal flaps are reflected, exposing a quadilateral area of bone which is removed by chisel and mallet. If need be, part of the vomer is also taken away, and thus the naso-pharynx is opened sufficiently to allow of the removal of the polypus or growth. The reflected segments of the palate are subsequently sutured together.

Adenoids.—It has been already mentioned that the naso-pharynx is the seat of a large amount of lymphoid tissue, similar to that met with in the tonsil, which may either be distributed widely over the whole mucous membrane, or be gathered into a special mass on the roof, known as the pharyngeal or Luschka's tonsil. Adenoids consist in a hyperplasia of this tissue, exactly analogous to the chronic hypertrophic form of tonsillitis, with which, indeed, it is often associated. They usually occur in the form of broad, cushion-like masses springing mainly from the roof or posterior walls, or occasionally as pedunculated tumours hanging down into the posterior nares. The tumours are extremely soft and vascular, bleeding very readily. The surface is often plicated, and in the recesses or folds between the different portions of the mass bacteria lodge and give rise to various inflammatory troubles, both locally and in neighbouring lymphatic glands. Not uncommonly isolated masses similar in structure to the above are also to be seen on the posterior wall of the pharynx, and a certain amount of chronic rhinitis and laryngitis may be associated. The condition is rarely seen in others than children, and especially those living in the smoky atmosphere of large towns. If untreated, they usually atrophy in time, but not before much harm may have been done to the individual.

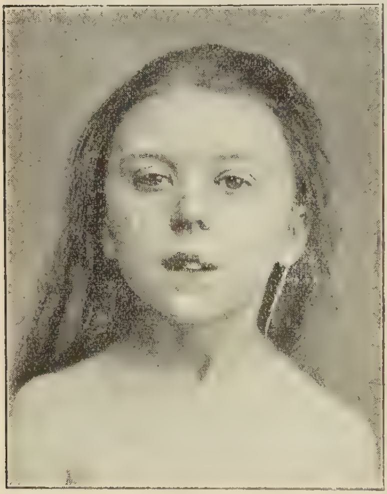

FIG. 398.—ADENOID FACIES. (FROM A PHOTOGRAPH KINDLY LENT BY SIR ST. CLAIR THOMSON.)

This illustration shows well the sleepy look, the pinched nostrils, the open mouth and projecting upper central incisors, so characteristic of this condition.

The **Symptoms** are mainly due to obstruction to nasal respiration. The mouth is generally held half open, so as to allow the child to breathe through it, thereby exposing the upper central incisors (Fig. 398); from a similar cause he snores during sleep, and usually wakes with the mouth and tongue dry. The nostrils are drawn in, and the nose is thin and pinched, the whole facies being very characteristic; the children often look sleepy and half silly, and, indeed, may be very backward in their studies. Not uncommonly there is a certain amount of semi-purulent discharge from the nose, or it may be hawked up from the pharynx, perhaps mixed with blood. Acute or chronic otitis media often results from extension of the catarrhal condition to the mucous lining of the Eustachian tubes, and deafness may be thereby induced; both taste and smell are sometimes impaired. The palate becomes high and arched, owing to the defective intranasal air pressure, and as the patient grows up, the incisor teeth may project forwards, giving a curious rabbit-like expression to the face. The cervical glands are sympathetically enlarged, and often the seat of tuberculous disease. In bad cases which have been allowed to persist throughout adolescence the thorax becomes flattened owing to the inability of the child to take a really deep inspiration, the ribs are drawn in, and the spine is kyphotic (Fig. 399).

Physical Examination consists in posterior rhinoscopy, by means of which the growths can be seen, or in palpation of the posterior nares, a process more suitable to children, who rarely have sufficient control to permit of the former. On passing the finger behind the velum, the naso-pharynx is found to be occupied by a soft mass of tissue which readily bleeds, and more or less obstructs the openings of the posterior nares.

Treatment consists in the great majority of cases in removal of the adenoids by operation. In mild cases, however, much may be done by enforcing respiratory exercises with the mouth shut; and in young adults attention to the general health, combined with irrigation of the nose with salt and water, and perhaps the local application of a weak solution of nitrate of silver (5 grains to 1 ounce) to the naso-pharynx, may suffice to bring about improvement.

Operation.—As a general rule the child should be anæsthetized with gas, chloroform, or chloride of ethyl, and the head may be allowed to hang backwards over the end of the table. If enlarged tonsils co-exist, these should be dealt with in the first place. Gottstein's curette, or some modification of it, is then introduced behind the soft palate, the velum being drawn forwards by the left index finger. It is pressed upwards so that its free convex edge impinges on the upper part of the posterior border of the nasal septum. It is then swept backwards and downwards over the pharyngeal wall, so as to shave away the chief portion of the projecting mass of adenoids. Possibly the application of a second smaller curette may be required to deal with outlying lateral portions of the mass; and finally the adenoid tissue about the orifices of the Eustachian tubes and any remaining tags are removed by the use of Löwenberg's forceps or the finger-nail. Of course, there is considerable bleeding, but this quickly stops of itself; as soon as the operation is over, the child should be turned over and held face downwards, so as to allow the blood to run out of the mouth and nose, whilst the face and forehead are sponged with ice-cold water to check the hæmorrhage. The patient is kept indoors for a few days, and only fluid food allowed. No local after-treatment is required as a rule, but the

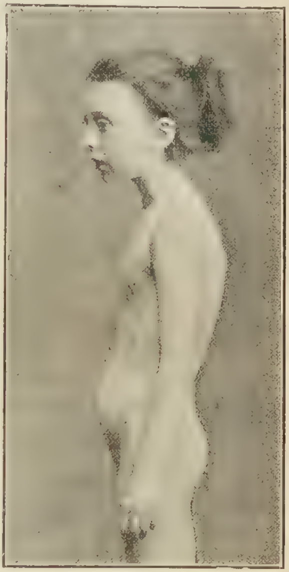

FIG. 399.—LATERAL VIEW OF A CHILD WITH NEGLECTED ADENOIDS. (FROM A PHOTOGRAPH LENT BY SIR ST. CLAIR THOMSON.)

This is the same child whose face appears in Fig. 398. It will be seen that the chest is shallow and retracted, and the spine kyphotic. The arms are small, but the legs are well developed.

throat may be gargled or the nose washed out with weak salt and water. Nose-breathing exercises should be subsequently instituted.

Epistaxis, or bleeding from the nose, may arise from a variety of causes, including traumatism, directed either to the mucous membranes or the bones, or from the presence of ulceration or tumours. Some of these local causes are very evident, if only they are carefully looked for with a rhinoscope and frontal mirror. One of the commonest lesions is a small abrasion or ulcer of the septum, due to detaching by the finger a scab or dried crust of mucus which causes irritation within the nostril; each time the nose is 'picked' in this way, bleeding recurs. Another frequent source of epistaxis is the rupture of a varicose vein in the mucous membrane of the septum; varix occurs not unusually in plethoric individuals, and sneezing or blowing the nose violently may lead to an attack. Foreign bodies may cause hæmorrhage, as also ulceration of an angioma on the septum. It frequently occurs in young people about puberty in consequence of local disturbance in the vascular arrangement of the parts; again, cerebral congestion may induce it, owing to the communication by means of emissary veins between the interior of the skull and the venous plexuses in the nose; excessive changes in the atmospheric pressure, as in mountaineering, may lead to epistaxis, whilst in abnormal states of the blood it may be associated with hæmorrhage elsewhere, as in hæmophilia, purpura, and scurvy. It is sometimes an evidence of chronic Bright's disease, and may be one of the first symptoms to call attention to its existence; it may follow cardiac or pulmonary disease, resulting in cerebral congestion, and may be a prominent symptom in enteric fever. One or both nostrils may be the seat of the bleeding, and it may be so excessive as even to threaten life.

Treatment.—It must not be forgotten that, in the majority of cases, there is some local cause of epistaxis which can be found and treated directly—a fact which once more emphasizes the necessity for gaining a mastery over the use of the rhinoscope. The bleeding is generally unilateral, and in nine out of ten cases the source is within easy reach of the anterior nares, and hence in many instances all that is required is to grasp the nostrils firmly, and thus allow the blood to collect within, and give it an opportunity of clotting. At the same time, the patient should sit up, and cold be applied to the root of the nose, or to the nape of the neck. If on examination the bleeding-point is detected, whether it be a varicose vein or an ulcerated surface, the hæmorrhage can almost at once be stayed by applying a pointed galvano-cautery, or by sealing the spot with a swab soaked in a solution of chromic acid (5 per cent.) or adrenalin. Failing these measures, the nostrils may need to be plugged, but such a proceeding ought to be seldom required. It may suffice merely to pack the anterior nares with long strips of sterile lint or gauze soaked in adrenalin, or a sterilized rubber finger-stall may be introduced and filled with wool. If this does not suffice, the posterior nares must also be plugged. For this purpose Bellocq's sound is usually employed in order to pass a thread round the base of the palate, and out of both nose and mouth; but where it is not obtainable, a suitably curved pair of laryngeal forceps or a rubber catheter may be used instead. To the lower end of this thread a pledget of sterilized lint or gauze about 1½ inches by 1 inch in size is attached, and this, guided by the finger round the soft palate, is drawn tightly forwards into the posterior nares. It is a good plan to have two threads coming forwards out of the nose, and these may be tied firmly around a pad of lint placed over the side of the nostril, thereby occluding the anterior nares and completely blocking the nasal cavity, back and front. The loose end of the thread emerging from the mouth is fixed to the cheek by a strip of adhesive plaster. The plug is retained for twelve hours, and then removed, and the nasal fossæ irrigated with a weak warm alkaline antiseptic lotion in order to prevent infection.

CHAPTER XXX.

AFFECTIONS OF THE MOUTH, THROAT, AND ŒSOPHAGUS.

Stomatitis, or inflammation of the mucous membrane of the mouth, is by no means uncommon, especially in children.

1. **Catarrhal Stomatitis** results from mechanical irritants, such as roughened teeth, from irritating chemicals, or from septic inflammation following operations which involve the mouth. It also arises in the course of fevers, and in conditions of debility such as follow measles and other exanthemata in children; or is associated with disturbances in the alimentary canal, as from improper feeding, dyspepsia, etc. The mucous membrane becomes hyperæmic and swollen, usually in small localized patches, which may gradually spread and become confluent, involving nearly the whole of the oral cavity. The exudation of mucus is increased, and becomes viscid and turbid, whilst the epithelium, at first white and sodden, is after a while rubbed off, leaving superficial erosions or distinct ulcers, which are very painful. The *treatment* consists in the removal of all sources of irritation, and the administration of drugs to correct intestinal derangements. Antiseptic mouth-washes should also be employed, such as sanitas (1 in 20), boro-glyceride (1 in 20), chlorate of potash, Condy's fluid, or peroxide of hydrogen.

2. **Aphthous Stomatitis** occurs in badly-fed children in the form of small whitish spots on a hyperæmic base, which run together and produce ulceration. Attention must be directed to the general condition, and a little borax and honey or a solution of boro-glyceride (1 in 20) applied locally. **Thrush** is due to the presence of a parasitic fungus, the *Oidium albicans*, and occurs in patches somewhat resembling curdled milk in appearance. In history and treatment it resembles the aphthous variety. In both these types there is often considerable enlargement of the lymphatic glands, which, however, frequently subside without suppuration when the cause is cured.

3. **Gangrenous Stomatitis,** or cancrum oris, has been already described (p. 123). A similar condition occurs in elderly debilitated people, especially if suffering from albuminuria or diabetes, and the possessors of foul teeth. *Treatment* must be of a similar character.

4. **Mercurial Stomatitis** may arise during the administration of a course of mercury, or occasionally from a single dose in persons who are sensitive to its action. It is increased in severity if the mouth and teeth are dirty, or if the patient smokes to excess. The gums are swollen and tender, bleed on pressure, and are very painful, especially when biting, or drinking hot fluids. The teeth may become loose and fall out, whilst the alveolar borders may be laid bare and necrose. The tongue is sometimes swollen and inflamed; salivation is a marked symptom, and the breath becomes very offensive. *Treatment.*—Either leave off the mercury, or at any rate reduce the dose considerably, and administer saline purgatives. Chlorate of potash, combined with alum, dilute hydrochloric acid, or tincture of myrrh, may be useful locally.

5. For **Syphilitic Stomatitis,** see p. 159.

The buccal mucous membrane is also involved in the course of other diseases, *e.g.*, diphtheria, scarlet fever, and erysipelas, but special descriptions are not needed here.

Affections of the Tongue.

Congenital Abnormalities.—(*a*) The tongue has been completely or partially absent. (*b*) One half of the tongue is defective in size (*hemiatrophy*). (*c*) *Tongue-tie* is said to be present when the frænum is shorter than usual, causing the tip to be depressed and fixed in the floor of the mouth so that it cannot be protruded. Sucking becomes difficult in such a condition, and when it is allowed to persist, there is often a lisp in the speech. Treatment is only needed in the severer forms, and consists in raising the tongue with the index and middle fingers placed one on either side, and snipping the frænum, thus put on the stretch, across its centre with a pair of blunt-pointed scissors directed downwards. (*d*) The tongue may be adherent to the floor of the mouth, being *bound down* by folds of mucous membrane (*ankyloglossia*). This may also exist as an acquired condition due to cicatricial contraction after ulceration. In congenital cases the adhesions are but slight, and the organ can be readily freed; in the acquired condition this cannot always be accomplished. (*e*) The frænum and tongue are occasionally too long, allowing of increased mobility, and even fatal results have occurred from the organ rolling backwards and impeding respiration. (*f*) The tongue may be *cleft*, presenting a bifid appearance; this may be complete or partial, and is usually associated with a congenital fissure through the lower lip and mandible. (*g*) *Macroglossia* (or large tongue), although sometimes acquired, is usually a congenital deformity. The organ is enlarged in all directions, and protrudes from the mouth, so that the teeth indent it, and cause ulceration and considerable interference with the venous return. It thus becomes purplish and dry from exposure, the mucous membrane looking almost like skin, although saliva dribbles freely from beneath it. In old-standing cases the teeth are displaced outwards and the jaws deformed, so that, even if the tongue is reduced to its normal size by treatment, it may be impossible to close the mouth. Pathologically, it is due to diffuse overgrowth of the connective tissue, secondary to lymphatic obstruction and dilatation. Recurrent attacks of lymphangitis add to the trouble, the tongue gradually increasing in size, and the disease has been known to terminate in the development of a lympho-sarcoma. The *treatment* consists in excision of a **V**-shaped portion, suturing the raw surfaces subsequently with catgut.

Wounds of the tongue are usually caused by the teeth, especially during an epileptic seizure, or in children as a result of falls with the tongue out. There is often brisk hæmorrhage for a few moments, which soon ceases, though blood may be extravasated into its substance, and cause considerable swelling. In simple cases the wound should be examined and purified, and the mouth constantly cleansed with mild antiseptic lotions; a few points of suture may also be inserted if necessary, but the wound must not be entirely closed, or tension from infection will result. When smart arterial bleeding is present, the mouth must be opened, the tongue pulled forwards, and the wounded vessel sought for and tied. Failing this, the lingual artery may be tied in the neck, or even the external carotid.

Acute Superficial Glossitis occurs as part of a general stomatitis, and needs no special notice.

Acute Parenchymatous Glossitis, or acute inflammation of the tongue, may arise from penetrating and, of necessity, infected wounds, or from the bites or stings of insects, or may be associated with acute stomatitis in the course of fevers, but is most commonly due to the injudicious administration of mercury. The condition may be limited to one half of the organ, but when arising from general causes is bilateral. The tongue becomes painful, swells up rapidly so as to fill the mouth, and even protrudes beyond the teeth, the pressure of which leads to superficial ulceration. The salivary glands are enlarged and painful, and salivation is a marked feature in the case. Speech, swallowing, and even respiration are much interfered with, and there may be considerable febrile disturbance. The case, if treated with care, usually ends in resolution; but diffuse or localized suppuration may ensue, as well as the most urgent dyspnœa, arising either from œdema glottidis or from the pressure of the enlarged organ. *Treatment* consists in stopping the mercury, or removing any evident cause, and in the administration of saline purgatives with chlorate of potash. Leeches may be applied beneath the angles of the jaw, but in bad cases a free incision into the dorsum should be made on either side of the median line to give exit to the effused fluids and blood. The most rapid relief to the symptoms is thereby obtained, although the organ may remain enlarged for some time. If asphyxia is threatening, high tracheotomy or laryngotomy is required.

Abscess of the tongue may result from the acute process described above, but is more usually of a chronic nature, and situated at the anterior part of the organ. It is generally due to the admission of micro-organisms through some superficial lesion which has quickly healed. It presents as a tense swelling, fluctuation in which may be masked by the amount of inflammatory thickening which surrounds it. A free incision both settles the diagnosis and cures the case.

Sublingual Abscess, when acute, is due to infection of the submucous tissue, as by puncture with a fishbone, or starts in a follicle of the sublingual or in a submucous gland. A puffy swelling forms beneath the tongue, which, if not opened early, may lead to an extension downwards of the mischief into the submental region. The tongue becomes swollen and turgid from pressure upon the veins, whilst œdematous laryngitis may also be induced. Considerable constitutional disturbance generally accompanies this process. A median incision through the mucous membrane, and the insertion and opening of a pair of dressing forceps, is the safest and best method of treatment, the cavity being subsequently washed out and drained. The more diffuse form of sublingual abscess is usually associated with submaxillary cellulitis (p. 89).

Chronic Superficial Glossitis is an interesting and important disease, which may be associated with a similar condition of the mucous membrane lining the interior of the cheeks and lips. It is most commonly due to syphilis, occurring as a tertiary phenomenon, but may arise from excessive smoking, ragged and rough teeth, or spirit-drinking, chronic dyspepsia, perhaps of a gouty nature, being also present in many cases. It is very liable to be followed by epithelioma, Barker stating that out of 110 cases he carefully investigated cancer occurred in 43.

For purposes of description it is useful to divide the disease into the following five stages, although it must be clearly understood that they are artificial, and several of them may be present in different parts of the same tongue. (i.) The papillæ become enlarged and swollen, leading to the appearance of red hyperæmic patches, which cannot be recognised for certain unless the tongue is thoroughly dried with a handkerchief, towel, or piece of clean blotting-paper, which must not be carelessly dabbed over the organ, but should be firmly pressed down so as to absorb all the moisture. (ii.) Overgrowth of epithelium follows, and as it increases in thickness, it becomes opaque and horny (Plate VI., Fig. 1), so that the red patches are replaced by white ones, leading to the appearance which has been designated *Leucoplakia*. Sometimes the papillæ become much enlarged, and stand out definitely and separately from the organ; or the whole surface may be covered with dense white patches. To this condition the term *Ichthyosis* has been applied. (iii.) Later on, the excess of epithelium is shed, leaving red smooth patches in which the papillæ are atrophied, or have entirely disappeared. If this occurs over the greater part of the organ, the *glazed red tongue* so characteristic of tertiary syphilis is produced. If, however, this process only occurs in smaller areas intermixed with portions covered with white epithelium, a patchy appearance of the tongue results, wrongly termed *Psoriasis linguæ*. (iv.) At varying periods of the disease, sometimes earlier, sometimes later, the organ becomes ulcerated, *cracked*, or *fissured* in a somewhat characteristic manner. A median fissure is usually seen running down the middle, and from this furrows extend transversely, dividing the surface into rectangular compartments. These fissures are not always due to the cicatrization of cracks, as when opened out healthy papillæ are seen at the base, and no sign of superficial scarring. They are, then, evidently the result of the contraction of deep sclerosed tissue in the substance of the organ. Superficial ulceration often occurs, apart from these fissures, being probably due to some local irritation, or to smoking; the atrophic condition of the mucous membrane explains the great liability to this occurrence. (v.) Still later, epithelioma may develop, and usually in connection with one of the cracks, or of the cicatrices arising therefrom. It is often somewhat slow in its progress, owing to the amount of sclerosis induced by the preceding inflammation.

The typical *smoker's patch* is a red irritable area on the front of the tongue, from which papillæ are often absent, and perhaps covered with a yellowish-white crust. Sometimes the epithelium is heaped up here into a well-marked leucoplakic spot.

All these stages of the disease are accompanied with much discomfort, the tongue being sometimes so tender that the patient cannot drink hot fluids or take condiments or stimulants without pain. The speech, too, is interfered with, becoming thick and indistinct. The course of the case varies considerably, and the affection may settle down after a time, and cause but little discomfort, so long as the patient conforms to the restrictions as to diet, etc., which are essential. If, however, he is careless or refuses to obey orders, the trouble may progress, and epithelioma develop.

The **Treatment** of the case is usually a matter of some difficulty. All sources of irritation are excluded from the mouth as a first precaution. Thus, smoking or chewing tobacco must be rigidly prohibited. Spirit-drinking and all acid wines which cause pain should be forbidden, dilute whisky and water being perhaps the best stimulant. The teeth must be well brushed night and morning, and all stumps and rough excrescences removed; definite pyorrhœa must be carefully treated. Gaps between the teeth should be filled by artificial teeth fitted to a smooth plate. Condiments, such as mustard, spices, curry, and cheese, are excluded from the dietary, and only simple unirritating ingesta allowed. The mouth is washed out frequently with an alkaline lotion—*e.g.*, bicarbonate of soda (20 grains to 1 ounce), or borax (10 grains to 1 ounce)—especially after meals, so as to exclude all risk of acid fermentation in the débris of food. Cracks and sores may be treated by painting the surface with a solution of chromic acid (grs. v. ad ℥i.) or of perchloride of mercury (grs. ii. ad ℥i.), but it is better to excise them completely, as also any wart-like formations. Solid nitrate of silver should particularly be avoided, as its use is likely to predispose to epithelioma.

General antisyphilitic remedies are employed where necessary, even including salvarsan; the digestion is attended to, and if the new formation of epithelium is excessive, arsenic may be administered.

On the appearance of definite epithelioma suitable operative measures must be instituted.

Ulceration of the tongue arises from a variety of causes, and occurs in many different forms. Thus, *dental* or *traumatic* ulcers, due to the irritation of rough and carious teeth, are generally seen at the margins of the organ. *Dyspeptic* ulcers are associated with gastric disturbances; they are usually located on the middle of the dorsum, and are often very painful. It is sufficient to touch them with lunar caustic after dealing with the cause. *Tuberculous* ulcers are not common, and are nearly always secondary to pulmonary or laryngeal phthisis, the organ being infected by the sputum. They commence in the form of a submucous abscess, which bursts and leaves a small painful sore, rarely situated on the posterior part of the organ, but chiefly at the sides or on the dorsum near the tip. Secondary abscesses form around and coalesce with the original ulcer. *Treatment* is chiefly needed on account of the pain and discomfort caused by them; it consists in their complete excision, or in cocainizing and scraping the sores, touching the base with pure carbolic acid, and dressing with iodoform. Applications of cocaine may also be made before meals, as a palliative measure where radical treatment is not undertaken on account of the extent of the pulmonary mischief. *Lupus* also attacks the tongue, but is very uncommon, and almost invariably secondary to a similar affection of the skin of the face. In a case under our care it appeared in the form of an irregular granulating surface surrounded by nodulated cicatricial tissue of an exceedingly dense character. The progress was very slow, owing to the amount of sclerosis present. Treatment consists in the application of the X rays or of radium; but in some cases it may be advisable to undertake a preliminary course of treatment by scraping and cauterization. *Syphilitic* and *cancerous* ulcerations are described below.

Syphilitic Disease of the tongue occurs in a variety of different forms. A *primary* sore presents a characteristic indolent and inactive surface, usually near the tip, with subjacent infiltration, and much chronic enlargement of the submental lymphatic glands, which, however, do not generally suppurate. In the *secondary* stage mucous tubercles, fissures, and ulcers form, and usually on the sides or near the tip. Occasionally one meets with a broad wart-like condyloma on the dorsum, which may be associated with longitudinal fissures; it is sometimes termed 'Hutchinson's wart.' In the *tertiary* period chronic superficial glossitis may develop, as also diffuse infiltration of the organ, or gummata.

Gumma of the tongue is not uncommon, occurring usually in patients under forty years of age, as a late tertiary phenomenon. It starts as a localized submucous or intramuscular infiltration near the median line, and generally towards the middle or posterior part (Fig. 400). The swelling is at first hard and firm, but later on becomes soft and fluctuating, and in time the overlying mucous membrane, which was unaffected, yields, and gives exit to the characteristic contents. The ulcer thus produced is oval or round in shape, and deeply excavated, the base being constituted by a slough. There is but little induration either of the base or edges, and neither the floor of the mouth nor the base of the tongue is involved, so that the organ can be freely protruded, whilst deglutition and articulation are scarcely interfered with. The patient complains of little pain, and the submaxillary glands are only affected either as part of a general enlargement throughout the body, or from the local irritation. The progress is slow, and the effect of antisyphilitic treatment very decided, the gumma being absorbed, or the ulcer, if present, healing readily, but leaving a localized area of sclerosis or a deep cicatrix, from which malignant disease may subsequently originate. In some cases a diffuse infiltration of the organ occurs, leading to a generalized sclerosis rather than to a localized gumma. The *treatment* consists in the administration of iodides with or without mercury, whilst the mouth is kept clean with a simple mouth-wash.

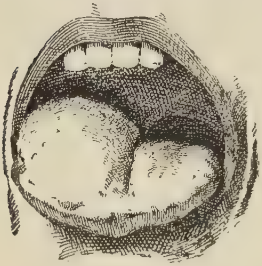

FIG. 400.—GUMMA OF RIGHT SIDE OF TONGUE. (FROM WAX MODEL IN COLLEGE OF SURGEONS' MUSEUM.)

Innocent Tumours are not frequent in the tongue, papilloma, cysts, lipoma, and nævi being the chief varieties, and requiring no special description.

Dermoid Cysts also form within or under the tongue, occupying the middle line, projecting either into the floor of the mouth or beneath the chin. They are due to non-obliteration of the upper end of the thyro-glossal duct (p. 886). The contents are of the usual sebaceous type. Such tumours should rarely be dealt with from the mouth, as they extend deeply, and need to be carefully dissected out. A free incision should be made beneath the chin, and the whole cyst removed unopened.

Cancer of the Tongue occurs in the form of squamous epithelioma, and is both a frequent and a very fatal variety of this disease. It is usually met with in men, and may arise as a result of the irritation caused by excessive smoking, especially when neglected, rough, and carious teeth are present. An underlying strain of syphilis is also frequently present in these cases.

Its mode of onset varies somewhat according to the situation: (*a*) It arises most commonly as an ulcer at the margin of the organ, towards the junction of the middle and posterior thirds, and is then generally due to the irritation caused by ragged and irregular bicuspid or molar teeth (Plate VI., Fig. 1); (*b*) it may start in a crack,

PLATE VI.

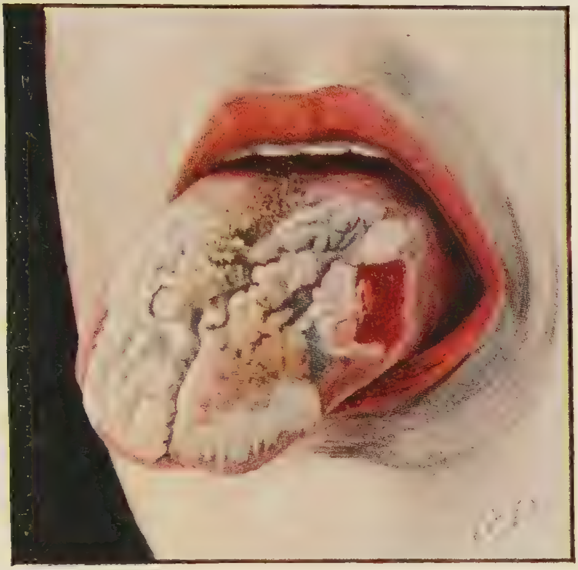

Fig. 1.—Epithelioma of Tongue, secondary to chronic superficial glossitis. The tongue was a characteristic one, showing heaping up of the epithelium, which was white and sodden (ichthyosis), as well as cracks and fissures in the middle line, due partly to chronic interstitial glossitis; the epithelioma developed late in the case on the left side opposite a diseased and dirty tooth.

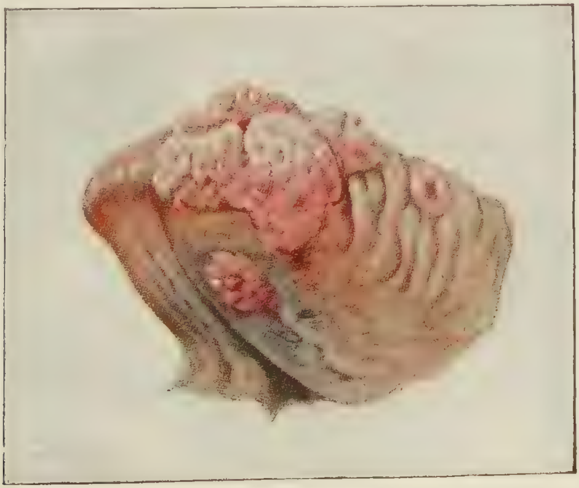

Fig. 2.—Epithelioma of Tongue of a hypertrophic papillomatous type.

[*To face page 838.*

fissure, or cicatrix on the dorsum, as a result of chronic superficial glossitis, or of a preceding gumma; (*c*) it may commence as a wart-like growth (Fig. 2), the base of which becomes infiltrated, the tumour invading the muscular substance, and spreading to the root of the tongue; (*d*) it may originate as a submucous infiltration, starting as an ingrowth from the mucous membrane, without much external manifestation of its presence; (*e*) it may first be noticed as an irregular ulcer in the floor of the mouth; or (*f*) it may spread into the tongue from surrounding parts, such as the tonsil or larynx.

In whatever way it starts, the same features are soon manifested, viz., a new growth is noticed, hard in consistence, indefinite in its extent, which may or may not be painful from the first, and which ulcerates superficially, exposing a more or less crateriform cavity, with a gray, sloughy, foul surface, readily bleeding when touched, and discharging a foul secretion, which causes extreme fœtor of the breath. The ulcer is surrounded by an indurated mass, which gradually shelves off into the neighbouring healthy structures, or may be abruptly limited. Profuse salivation is produced by the irritation of the branches of the third division of the trigeminal, and all the movements of the tongue are painful and limited on account of the infiltration of the base, so that both swallowing and speech are difficult, the patient allowing the saliva to dribble out of his mouth. The pain is often severe, and usually extends along many of the branches of the fifth nerve, especially to the ear, so that sleep becomes impossible, and the patient's condition steadily and rapidly deteriorates.

The submental, submaxillary and subparotid glands early become involved in the disease according to the position of the primary growth; thus, cancer of the tip of the tongue usually affects the submental glands; if situated further back, the submaxillary glands are involved; whilst in the region of the pillars of the fauces the subparotid glands are first attacked. Ultimately the disease spreads to the deep glands lying along the main vessels, a gland lying over the bifurcation of the common carotid artery being early enlarged. These glands, if not removed, soon attain considerable dimensions, and become stony hard and fixed to surrounding structures, especially the carotid sheath. If the disease is strictly limited to one half of the tongue, the lymphatic glands on the other side of the neck are seldom affected except in the last stages; but if the disease extends towards the centre of the organ, the glands on both sides are often equally involved. These secondary growths are very frequently cystic in character, from the degeneration of the masses of epithelium formed within them; after a time they approach the surface and burst, leaving ragged malignant ulcers in the neck. The lower jaw itself is often invaded in the later stages of the disease.

The occurrence of the typical cachexia is determined not only by the pain and consequent sleeplessness, but also by the inability to take sufficient nourishment, the absorption of products of putrefaction swallowed with the saliva, the excessive salivation, the occasional hæmorrhages, and the extent of the secondary growths. The patient rarely lives, apart from treatment, for more than twelve months after the disease has been first noticed. Death is due to exhaustion, hæmorrhage, or septic pneumonia.

Diagnosis.—When a case is met with where the ulcer is situated at the side or base of the tongue in a patient over forty-five years of age, with the typical enlargement of the glands, profuse salivation, and impaired movements, there can be little doubt as to the diagnosis. But when it is seen in the early stage, as an infiltration of a syphilitic fissure or cicatrix, or as a small wart, it may be difficult to determine whether or not malignant disease is present. The early enlargement of the glands, the amount and character of pain, the fixity of the organ, and the infiltration of the base of the ulcer, are important guiding marks; but in doubtful cases a small portion of the edge of the growth and of the adjacent parts should be excised under cocaine, and subjected to careful microscopic examination, and thus its nature ascertained. Moreover, the fact of improvement after the administration of steadily increasing doses of iodide of potassium, does not absolutely disprove the existence of cancer, as the two conditions so often co-exist.

Treatment.—The only hope of curing the patient lies in thorough and early removal of the growth, which it should be remembered has probably extended much further than one expects. The excision must include not only the tumour, but also a wide area of tissue around it, so as to get well beyond the zone of infiltration; not only the lymphatic glands, which are obviously enlarged, but also the whole lymphatic area, extending practically from the base of the skull to the episternal notch. It is obviously desirable to undertake such extensive operative proceedings in two stages, if possible, dealing first with the tumour in the mouth, and subsequently with the glands. When the base of the organ is free from infiltration, and the disease appears to be separated from the glandular area by a sufficient margin of healthy tissue, the operation in two stages may be undertaken; and the fact that recurrence is rarely noted in the portion of the organ that intervenes between the two operative areas indicates that such a practice, though not ideal, is justifiable. The mouth is often in a very dirty state, and the danger of infection after making an extensive dissection of the main vessels of the neck is not slight. On the other hand, when there is considerable infiltration of the deeper parts of the tongue with extensive glandular mischief, it may be impossible to find a sufficient margin of healthy tissue to justify the division into two stages; and then the patient must run the risks associated with the removal of tongue and glands at one time.

In all cases great care must be taken in the preparation of the patient so as to minimize the risk of infective mischief. Suitable antiseptic mouth-washes are employed for some days; dirty roots and stumps are removed, and the remaining teeth carefully cleansed. Possibly, if time permit, a culture might be made of the chief organisms in the mouth, and a vaccine procured, which may help to guard the patient from post-operative infection. It is wise also to keep him indoors for a few days beforehand so as to protect him from risks of cold and bronchitis.

The actual operative details differ somewhat according to the extent and situation of the disease, but most of the operations for removing the growth are a modification of the intrabuccal method suggested by Whitehead.

If the *tip* only is involved, it can be removed by a **V**-shaped incision, made after steadying the tongue with a deep suture. The small ranine artery will spurt on each side, but is easily secured, and the gap closed by sutures.

When the disease involves one side of the tongue and is not very extensive, and does not spread deeply into the base, it will suffice to remove the *anterior half* or two-thirds of the affected side as a first stage without touching the glands. The patient having been anæsthetized, the mouth is opened with an efficient gag, and anæsthesia is maintained by giving chloroform through a Junker's apparatus, or ether by intratracheal insufflation. A good assistant is necessary in order to prevent blood entering the larynx, small swabs or pieces of sponge held in smooth-nosed, long-handled forceps or suitable sponge-holders being used to clear the pharynx. A coarse silk thread is passed through each half of the tongue to draw it forwards and steady it. The tongue, being drawn out of the mouth by these loops of silk, is carefully divided by blunt-ended straight scissors down the middle line into two segments, which are readily separated from one another by the finger, the scissors merely dividing the mucous membrane. The base of the organ is freed by cutting through the mucous membrane close to the alveolus, and then along the middle line of the floor of the mouth, so that the sublingual salivary gland can be also taken away—a most necessary step. The mucous lining of the dorsum is now divided transversely behind the growth, and the muscular structure of the organ slowly snipped through with scissors. During this process, by the aid of the finger or a director, the vessels can be seen and secured before division. Removal of the diseased half with the sublingual gland is thus easily accomplished by making the incisions meet, and dividing the intervening tissues. Bleeding-points are picked up and secured as they appear. It is often possible and advisable to expedite healing by closing the wound in the tongue partially or entirely, either by stitching the mucous membrane of the dorsum to that of the base, or, better, by twisting the half tongue on itself and stitching the tip to the back of the organ. The patient will probably be sufficiently recovered from this operation to enable the surgeon to deal with the glands in a week or ten days (p. 843).

If both sides of the tongue are involved, but the disease has not extended deeply into the base, it is not difficult to effect removal by a modification of the same procedure. The mouth is gagged open, and two silk slings are inserted, one through the anterior portion, and the other just in front of the epiglottis. The mucous membrane of the floor of the mouth is then incised on either side, and the muscles attached to the genial tubercles divided. By this means the tongue is considerably loosened and can be drawn well up out of the mouth, so as to enable the section to be made across it with scissors at the desired level. The main vessels can generally be seen and secured before division, and the amount of bleeding is not excessive. It is often possible to draw forward the stump of the tongue and secure the mucous membrane anteriorly, so as to diminish the size of the raw area in the mouth.

If the disease extends more deeply into the substance of the tongue, so that the whole organ has to be removed, it is wise to employ a preliminary division of the lower jaw, as originally suggested by Syme, and more lately recommended and practised by Kocher.* An incision is made in the middle line dividing the lower lip, extending downwards to the hyoid bone. The mandible is sawn through in the middle, and the two halves separated widely. As much of the tongue as is considered necessary can be easily removed by the scissors. After affecting hæmostasis, a silk thread or silver wire is passed through the stump of the tongue and epiglottis in order to control it and prevent interference with respiration; the halves of the jaw are wired together and the superficial wound closed. It is possible that a preliminary tracheotomy may be useful in these cases, but it is not essential.

When the tongue, or a portion of it, has to be removed with the glands *en bloc*, the lateral extrabuccal method, known as *Kocher's operation*, is perhaps the best. A preliminary tracheotomy is usually associated with it. An incision is made, commencing close to the lobule of the ear, running down along the anterior border of the sterno-mastoid to the great cornu of the hyoid bone, and thence forwards nearly to the middle line, and upwards to the symphysis. This flap of skin and subcutaneous tissue is dissected up, and stitched to the cheek out of harm's way. All the lymphatic glands in the region—the submental, submaxillary, and those lying over the carotid—are now removed, as well as the submaxillary salivary gland, the lingual and facial arteries being tied close to the carotid. If necessary, the incision is enlarged downwards along the anterior border of the sterno-mastoid in order to permit of more thorough removal of the glands. Any diseased portion of the jaw is isolated by saw-cuts in front and behind, and removed. Where only half the tongue is to be removed, it is now split down the middle line with scissors, and the mucous membrane in the floor and side of the mouth divided so as to leave that side of the tongue attached merely by the muscular structures. If the whole organ is to be removed, it is unnecessary to divide it in the middle line. By detaching the mylo-hyoid from the bone a communication is made between the outside wound and the mouth, and the tongue is then drawn through this lateral opening, and can be removed as far back as the epiglottis behind and the hyoid bone below, the whole floor of the mouth being effectually dealt with in this way. The wound in the neck is closed by buried and superficial sutures, a drainage-tube being inserted for a few days.

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* 'Kocher's Textbook of Operative Surgery.' Translated from the fourth German edition by Harold J. Stiles, M.B., F.R.C.S. London: Adam and Charles Black, 1911.

The **After-Treatment** is much the same in all cases. The raw surface may be painted with Whitehead's varnish (which consists of Friar's balsam, but with the rectified spirit replaced by a saturated solution of iodoform in ether); the all-essential thing, however, is to keep the cavity well irrigated with antiseptic lotions, such as weak solutions of boric acid, boroglyceride (1 in 20), sanitas or lysoform. The patient must be closely watched for the first forty-eight hours, to see that his respiration is not obstructed by the stump of the tongue falling backwards; but at the end of that time this danger will be at an end, and the silk or silver wire may be removed. It is not desirable to keep him in bed more than two or three days. The patient is fed *per rectum* for twenty-four hours, but afterwards a tube attached to the spout of a feeder is introduced into the pharynx or œsophagus. In the simpler cases he is able to swallow freely and without difficulty in the course of a day or two, and even in the worst cases he can feed himself with a long tube passed into the pharynx in five or six days. The chief dangers of the operation arise from septic contamination, resulting in secondary hæmorrhage or septic pneumonia; and these are best avoided by careful and thorough preparation of the patient.

The removal of a part, or even the whole, of the tongue is not such a mutilation physiologically as one might expect at first. Deglutition is interfered with for a time, but the power is soon regained, and even articulation may be in great measure restored.

The operation for **removing the glandular area** in connection with cancer of the tongue is a formidable proceeding, as its scope must extend from the mastoid process to the episternal notch. If the disease has involved both sides of the tongue, both sides of the neck must be cleared, and even when the disease has only apparently affected one side of the tongue, the glands on both sides of the neck may be involved. The incision should extend along the anterior border of the sterno-mastoid throughout its whole length, and a second incision meets it extending from the chin to just below the great cornu of the hyoid bone. The flaps thus marked out are dissected up and turned forwards, the platysma being included in them. The submental and submaxillary regions are cleared of their loose cellular tissue, including all lymphatic glands and the submaxillary salivary gland (except the deep process and duct), which are turned back towards the main vessels. The internal jugular vein is then laid bare and all the lymphatic glands lying upon it are dissected upwards from below or downwards from above. All the cellular tissue of the anterior triangle is cleared away in one piece with the glands, extending from that which lies under cover of the omohyoid below to those which are placed beneath the posterior belly of the digastric and lower edge of the parotid above. The facial and lingual arteries will have to be secured back and front; the external jugular vein will be sacrificed, and if need be the internal should also be taken away; but the facial and spinal accessory nerves must be spared. Careful deep suturing will minimize the deformity, but it will be necessary to drain the lower part of the wound, and if the parotid has been encroached on a tube must also be inserted above.

Affections of Salivary Glands.

Inflammation of the Parotid Gland is met with in several different forms.

1. **Epidemic Parotitis (Mumps)** is an acute specific disease usually seen in children, and highly infectious or contagious in character. The period of incubation is about three weeks, and the attack itself consists in a slight febrile disturbance, associated with swelling of one or both parotid glands; one gland is attacked first, becoming enlarged and tender, whilst the other side is similarly affected in a day or two. Mastication becomes difficult, owing to the tension of the parts. The swelling, which lasts for about a week and then gradually subsides, extends below and in front of the ear, and the socia parotidis can be distinctly felt lying over the masseter; the submaxillary, sublingual, and neighbouring lymphatic glands are sometimes, but not frequently, enlarged. Suppuration is rare, but in adults metastatic inflammation of the testis, mamma, or ovary is not uncommon. This complication is generally unilateral, and thus, although atrophy of the testis commonly follows orchitis, sterility is not produced. *Treatment.*—Keep the patient warm and quiet, and administer salines. In the later stages friction with stimulating liniments will hasten resolution. After the acute attack, the gland may remain enlarged for some time.

2. A **Simple Parotitis** occasionally results from exposure to cold or from injury, whilst the presence of a calculus in the duct leads to a chronic sclerosing inflammation. The symptoms consist of pain and swelling, together with a certain amount of constitutional disturbance. An extremely interesting phenomenon is the parotitis which follows injuries or diseases of the abdominal or pelvic viscera. This condition is not very unusual, and was formerly attributed to pyæmia, but is now considered to be due to infection spreading up from the mouth, owing to a dirty state of the teeth induced by prolonged rectal feeding. In confirmation of this view is the fact that it has been seen in not a few cases of gastric ulcer, where the patient had been fed *per rectum* for some time. *Treatment* in these simple cases consists in the application of fomentations, perhaps medicated with belladonna.

3. **Suppurative Parotitis** is a much more serious condition. It may extend from the mouth along Stenson's duct, or supervene in the course of pyæmia, or as a sequela of some of the exanthemata—*e.g.*,

scarlet or typhoid fevers. The gland becomes much enlarged, with congestion and œdema of the overlying skin, and, owing to the tension of the fascia, exceedingly painful. For the same reason, pus cannot readily find its way to the surface, and hence is likely to burrow in various directions—*e.g.*, amongst the muscles of the neck, or even upwards and inwards towards the base of the skull, or to the cavity of the mouth, finding its way over the border of the superior constrictor (the so-called 'sinus of Morgagni'). The constitutional symptoms from toxic absorption are usually very severe. Owing to the fact that large veins and arteries pass through the parotid gland, pyæmic symptoms are not unlikely to supervene, and the prognosis is therefore somewhat serious.

Diagnosis.—Inflammation of the lymphatic glands lying on the outer surface of the parotid closely simulates the above affections, but is distinguished from them by the fact that they are more superficial, and that the socia parotidis is not enlarged.

Treatment.—In the early stages fomentations are employed, but as soon as there is any indication that suppuration has occurred, a free incision must be made, and the pus let out. Every precaution should be taken to prevent mischief to the facial nerve, and Hilton's method of operating may be advantageously employed; but in the more severe cases where the patient's life is threatened and the pus is burrowing in all directions, the knife must be used freely, regardless of anatomical considerations.

Inflammation of the **submaxillary and sublingual** glands may arise in an exactly similar way, but no special description is called for. Occasionally, however, the process extends beyond the submaxillary glands to the neighbouring tissues, giving rise to what has already been described as submaxillary cellulitis, or Ludwig's angina (p. 89).

Ranula is a cystic swelling of the floor of the mouth, containing a glairy mucoid fluid, and sometimes due to obstruction and distension of one of the sublingual ducts (or ducts of Rivini). A similar condition has been caused in rare cases by a blocking of Wharton's duct, but this has generally been found to run along the outer surface of the cyst. The tumour may be as large as a walnut or pigeon's egg, and is unilateral. The *Treatment* consists in removing a good-sized piece of the wall, so that the cavity may be obliterated by a process of granulation, or if that should fail, the whole cavity must be dissected out.

Obstruction to the Flow of Saliva results from various causes, such as cicatricial contraction in the neighbourhood of the entrance of the duct into the mouth, or from the presence in the duct of a *salivary calculus*, consisting of phosphate and carbonate of lime, and usually fusiform in shape. Calculus formation only occurs in connection with the submaxillary and sublingual glands, since the saliva secreted by them is thick and mucoid, whereas parotid saliva is limpid in character.

The chief *Symptom* of such obstruction is a painful enlargement of the gland during and after meals, which slowly passes away as the saliva finds its way past the block; if it persists for long, the gland becomes chronically enlarged, and its interstitial tissue increased in bulk, whilst a certain amount of peri-adenitis also follows. When a calculus is present, there is usually a considerable discharge of offensive muco-pus into the mouth. Where the obstruction is complete, a cyst may form, and if this is opened, or finds its way to the exterior and bursts, a salivary fistula results.

Treatment.—In cases of simple obstruction an attempt must be made to restore the natural exit, or to make an artificial one. If a calculus is present, it can usually be seen or felt at intervals projecting from the entrance of the duct; in such a case the duct must be incised from the mouth, and the stone removed. Where, however, it is located in the substance of the submaxillary, total removal of the gland may be necessary.

Salivary Fistula occurs almost solely in connection with the parotid gland. It arises from penetrating wounds of the cheek dividing Stenson's duct, or more frequently it follows operations in its neighbourhood. It is a very troublesome condition, both for the surgeon who is called upon to treat it, and for the patient who suffers from the inconvenience of saliva flowing down the cheek, the amount being, of course, increased at meal-times. Stenson's duct extends forwards from the socia parotidis across the masseter muscle for a distance of about 2 inches, and then turns abruptly inwards to pierce the buccinator, and enter the mouth opposite the second upper molar tooth. The buccal and masseteric portions are almost at right angles, the latter being represented by a line drawn from the lobule of the ear to a point midway between the ala nasi and the angle of the mouth. The diameter of the duct is about $\frac{1}{8}$ inch, its narrowest portion being at the orifice.

Treatment.—If the buccal portion is involved, a cure is often attained by slitting up the duct within the mouth; but when the masseteric portion is wounded, and especially if near the socia parotidis, treatment becomes more difficult. The following plan is often successful: A fine probe is passed along the duct from the mouth as far as the lesion; it is then grasped by forceps inserted through the external aperture, and drawn out on to the cheek, a proceeding sometimes facilitated by slightly enlarging the wound. A double thread of silk is now tied to the end of the probe, and drawn through the thickness of the cheek, along the buccal portion of the duct, and out of the external wound. A fine drainage-tube is then carried along the same track, and left so as to project both externally and internally. A silk thread is attached to each end of the tube, and these are knotted together round the angle of the mouth. By this means a passage is re-established into the mouth, and as soon as it becomes easier for the saliva to travel along this than along the external wound, the fistula will close. At the end of a few days the outer half of the tube is removed, and only a silk thread allowed to occupy the outer portion of the fistula, which gradually contracts so that more and more of the saliva finds its way into the mouth. The silk thread and tube are then finally removed, and if the opening in the mouth is kept patent, the external wound soon heals. In those cases where the buccal portion of the duct is completely obliterated or obstructed so that a probe cannot be passed, a trocar and cannula are inserted through the external wound and cheek into the mouth; a silk thread is insinuated through the cannula, and a tube drawn into position, as in the former case. The subsequent treatment is the same as that indicated above.

Tumours of the Parotid Gland are of considerable interest, and may be simple or malignant.

(*a*) The **Simple** parotid tumour is usually an *endothelioma*, in which, however, fibrous and adenoid tissue may occur. It usually commences near the surface in the endothelium lining the blood-vessels and lymph spaces, and, owing to a colloid or mucoid degeneration of the interstitial tissue, may simulate a chondroma or myxoma. The tumour feels hard, firm, and nodular, but areas of softening may be interspersed amongst the harder portions. The mass is situated between the jaw and the sterno-mastoid, accessory processes also extending over the masseter in the region of the socia, and later on burrowing deeply between the mastoid bone and the styloid process, and beneath the ramus of the jaw (Fig. 401). In the early stages the tumour is freely moveable on the deeper parts, as is also the skin over it, but subsequently the mass becomes fixed and adherent. The growth is usually slow, and at first quite painless, and there is no tendency to invade lymphatic glands or produce cachexia. Mastication is impaired in the later stages, but otherwise the subjective symptoms are of but slight importance, owing to the fact that the growth is superficial to the gland, and to the more important vessels and nerves. If allowed to persist, the growth will finally take on malignant characters. True adenoma or fibroma of the parotid gland is occasionally observed.

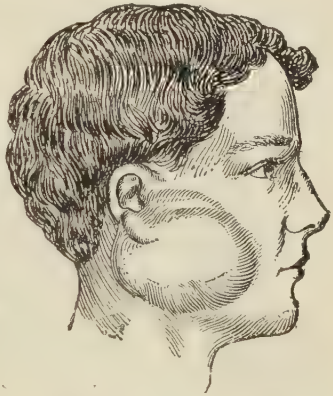


Fig. 401.—Parotid Tumour. (Fergusson.)

(*b*) **Malignant** tumours of the parotid (Fig. 402) occur in the form of endothelioma, sarcoma, or carcinoma, and are not unfrequently grafted on to a simple tumour, the change of type being marked by increased rapidity of growth and greater pain. The mass becomes more fixed, and signs of pressure upon the vessels and nerves develop; the facial nerve is very likely to be implicated, leading to paralysis of the face. Moreover, the skin becomes hyperæmic and often adherent to the tumour, and finally ulceration and even fungation may obtain. Secondary deposits occur in the neighbouring lymphatic glands or in the viscera, and the patient soon passes into a state of malignant cachexia. Carcinomatous tumours are less common than the sarcomata, but run a similar course. The growth is an adenoid cancer, not unfrequently of the soft or encephaloid type, and neighbouring lymphatic glands are early invaded.

The **Diagnosis** of simple parotid tumours from malignant growths is a matter of the greatest importance from a prognostic point of view, since simple tumours are usually encapsuled, and their removal, except when large or deeply placed, is not a matter of special difficulty; malignant disease is more diffuse, rendering extirpation of the mass almost impracticable. The distinction between the two forms is made by a consideration of the signs and symptoms considered above, attention being directed to the rate of growth, the condition of the skin and surrounding parts, the mobility or not of the neoplasm, and the general aspect of the patient, whilst associated paralysis of the facial nerve is almost always characteristic of malignancy. The lymphatic glands lying on the surface of the parotid, when invaded by tubercle or by epithelioma secondary to some intrabuccal growth, may closely simulate a true parotid tumour, but are recognised by their more superficial position.

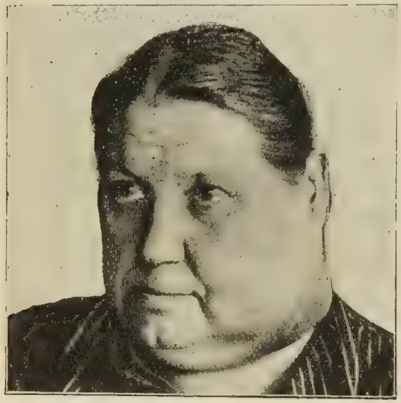


FIG. 402.—MALIGNANT TUMOUR OF THE PAROTID GLAND.

The **Treatment** is often a matter of some difficulty, owing to the important character of the surrounding tissues. Removal should only be attempted if the skin is not extensively involved, if the growth is moveable on the deeper parts, and if there is no evidence of secondary deposits. Even simple tumours become irremoveable after a time on account of their deep connections and change of type, whilst it is seldom justifiable to touch malignant growths on account of their early and wide local dissemination. *Simple* parotid tumours are dealt with by turning forwards or upwards a flap of skin and subcutaneous tissue, so as to expose completely the capsule and enable the dissection of the growth to be made with as little danger to the facial nerve as possible. It is generally placed beneath the growth, but occasionally runs superficial to it, or in its substance. The tumour is often enucleated without much difficulty, but the surgeon must make certain that no deeper processes are left, or recurrence will inevitably follow. The hæmorrhage from the transverse facial and other arteries is free, but easily restrained. There is no need to remove redundant skin in these cases, as it quickly contracts.

In dealing with early malignant disease *excision of the whole parotid gland* may be occasionally required. It is accomplished through a vertical incision, or if the skin is involved by two crescentic ones. The gland is then gradually freed from its connections, care being taken, if possible, to keep outside its capsule. It is best to deal with the lower part first, securing with double ligatures the external carotid artery and temporo-facial vein. The mass is then drawn upwards and forwards, and its deep connections severed. The facial nerve is, of course, divided, and the patient must be warned before the operation of the necessarily resulting facial palsy. Recurrence is almost certain to follow. Removal of the angle of the jaw as a preliminary step has been recommended, since considerable space is gained thereby, and a better access to the field of operation.

Tumours of the Submaxillary Gland are very similar in nature to those of the parotid. Simple tumours are represented by endotheliomata, resembling cartilaginous or myxomatous growths, according to whether they are hard or soft (Fig. 403). Sarcoma and carcinoma are also met with; if seen in the early stages they are easily removed.

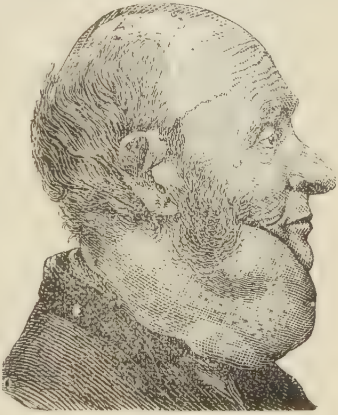


FIG. 403.—SUBMAXILLARY TUMOUR. (TILLMANNS.)

Affections of the Palate.

Cleft Palate.—By cleft palate is meant a congenital defect of the roof of the mouth, whereby the structures entering into its formation do not unite in the middle line, thus allowing an abnormal communication to exist between the nose and mouth. The term does not include losses of substance, resulting from injury, syphilis, or lupus. The mildest cases consist merely of a bifid uvula, perhaps not involving the palate at all; the next degree of severity affects the velum alone (Fig. 404, A); more or less of the hard palate may also be implicated, the cleft reaching as far forwards as the site of the anterior palatine canal (B); whilst the severest type of the deformity extends in addition through the alveolus and upper lip on one or both sides, the os incisivum being in the latter case displaced forwards, perhaps on the tip of the nose (C). The union of the palatal segments takes place from before backwards, so that it is very unusual to find the alveolar portion of the palate affected apart from the rest.

On looking carefully at a cleft palate, the defect usually appears to be mesial, but occasionally it seems as if a unilateral or bilateral fissure existed. To understand such an occurrence it must be remembered that three anatomical elements unite in the middle line of the roof of the mouth, viz., the two palatal processes growing in horizontally from the maxillæ, one on each side, and the ethmo-vomerine septum projecting vertically downwards from the under surface of the fronto-nasal process and base of the skull. All these should join together about the ninth or tenth week of intra-uterine life. If, however, the palatal processes fail to reach the middle line, a median defect appears (Fig. 405, A), unless the ethmo-vomerine septum is so hypertrophied as to project between them, when the appearance of a double cleft is produced (B). When only one division of the palate unites with the septum, an apparently unilateral cleft results; most commonly the defect is on the left side, the vomer being attached to the right free edge, a left-sided alveolar hare-lip also complicating the case (C). In these cases the septum often slopes off so as to appear to be continuous with the palatal segment.

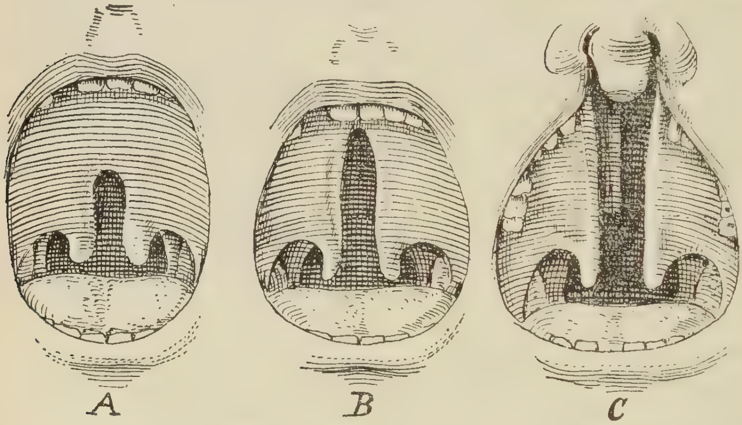


FIG. 404.—VARIOUS FORMS OF CLEFT PALATE: *A*, INVOLVING MERELY THE VELUM; *B*, TRAVERSING THE HARD PALATE AS FAR FORWARDS AS THE ANTERIOR PALATINE CANAL; AND *C*, BEING COMPLICATED WITH A DOUBLE HARE-LIP.

The *width* of the cleft and the slope of the segments varies greatly in different cases. The wider the cleft, the more unfavourable it is for treatment by operative means; and this is one of the arguments used in favour of the removal of the intermaxilla in cases of double hare-lip, so as to allow of the approximation of the two maxillæ. As to the *slope* of the segments, the more vertical they are, the more favourable for operation, since the flaps of muco-periosteum easily meet in the middle line. When the palate is more horizontal, and like a Norman rather than a Gothic arch, the flaps are shorter and greater lateral displacement is necessary to bring their edges into apposition; this involves much more traction on the stitches, and hence less satisfactory results.

The *effect* of such a deformity upon the infant, from a physiological point of view, is very serious. The process of *nutrition* is considerably impaired, owing to the fact that the power of suction is lost, and fluids taken into the mouth are apt to escape through the nostrils instead of being swallowed. Consequently these children must be carefully spoon-fed with the head thrown well back. *Articulation* becomes very indistinct, so that it is often impossible to understand what is said, the voice having a peculiar and characteristic intonation. All the letters known as explosives, whether dentals, labials, or gutturals, requiring a certain amount of air pressure within the mouth for their due pronunciation, are difficult to produce, particularly *b, d, p, t, g, f,* etc. Moreover, the exposure of the nasal mucous membrane to the air is so much greater than usual that it is liable to chronic rhinitis sicca (p. 820). Both taste and smell are much diminished, partly from the unhealthy state of the mucous membrane, and also from the absence of an opposing surface against which the food can be triturated by the tongue.

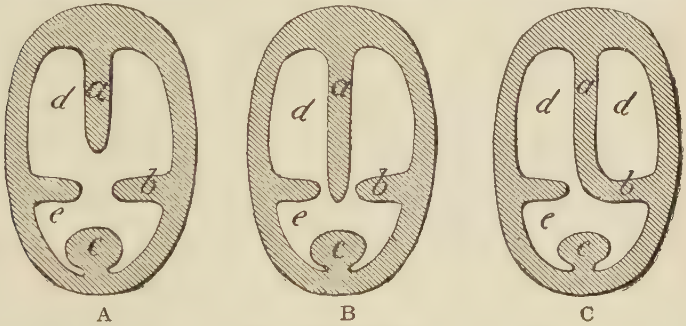


FIG. 405.—DIAGRAM TO SHOW THE MODIFICATIONS OF CLEFT PALATE.

a, Ethmo-vomerine septum; *b*, palatal segments; *c*, tongue; *d*, cavity of the nose; *e*, buccal cavity.

Treatment.—Considerable divergence of opinion exists as to the period at which operation should be undertaken for dealing with this defect, and also as to the best method to be employed. Some surgeons advocate its performance at as early a date as possible, even within a few weeks of birth; but, whilst admitting that in some hands this seems to have met with a certain degree of success, the plan does not seem generally applicable. The parts are very small; the tissues are very delicate and friable. The operation is therefore increasingly difficult, and the child is incapable of standing much shock or loss of blood. On the other hand, operation should not be deferred too long; bad habits of articulation will be contracted, and subsequent physiological success, as gauged by the quality of the speech, is much less likely to follow. On the whole, we see no reason to modify the opinion expressed from the start in this text-book, that the best period for operation is between the second and third years, when a child can be easily kept under control. It is most important that the general health be good, and the mouth and throat free from local disease or inflammation. To guard against accidents, it is well to make a routine practice of keeping a child indoors under observation for a few days before operating. and for choice the spring or summer should be selected. Enlarged tonsils are usually removed before operation, but a pad of pharyngeal adenoids may sometimes be left with advantage, as they assist subsequently in closing the nasal cavity.

The object of operative treatment is to close the gap in the hard palate by the union of flaps of muco-periosteum or by compressing the maxillæ; it is also desirable that the velum palati should not only be continuous, but mobile. Of the various methods that have been suggested to attain these ends, only three need be noted.

Brophy's operation is one which aims at closing the palate by drawing together the bony maxillæ. The child is anæsthetized; the margins of the cleft are pared, even down to the bone, and stout silver sutures, two or three in number, are carried through the maxillæ from side to side, just above the palate. The ends of the silver wire are passed through holes in lead plates, and drawn tightly together by twisting. The maxillæ are forced together by digital pressure so as to approximate the margins of the palate, and the wires are tightened as much as necessary. The soft palate is subsequently closed by sutures. The wires are kept in place for three or four weeks and then removed. This operation is not desirable after the age of six months, and should be performed before the treatment of the associated hare-lip. It has been but little used in this country, and its advantages are doubtful.

Lane's method of treatment is applicable to young children within a few weeks of birth. It is in reality an elaboration of the method suggested by the late Mr. Davies Colley. It consists in raising suitably shaped flaps of muco-periosteum from either side of the palate, in such a manner that when turned over they can be sutured one to the other, and form a complete barrier between the mouth and the nose. Text-books on operative surgery must be consulted for exact details of this procedure, which will have to be modified according to the requirements of each particular case, but the accompanying diagrams (Figs. 406 to 410) will sufficiently suggest the character of the operation. It will be noted that the muco-periosteum is detached on one side from the bony palate, and allowed to hang down, whilst a small flap consisting only of mucous membrane is raised from the back of the soft palate. On the other side a similar, but rather more extensive flap, encroaching on the alveolus, is raised from without inwards, and turned over, the free margin

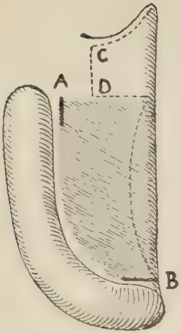


FIG. 406.

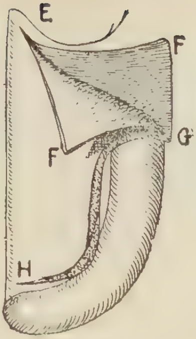
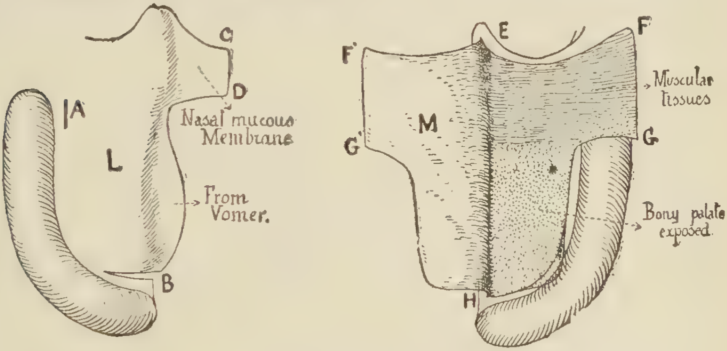


FIG. 407

Fig. 406 indicates the treatment of the left side of the palate. At A and B small incisions are made, through which the complete muco-periosteum of the hard palate is separated from the bone. The dotted lines from CD indicate the outlines of a flap of mucous membrane to be raised from the upper nasal surface of the velum; a smaller flap is raised from the margin of the hard palate.

Fig. 407 shows the incision (EF GH) needed on the right side, and shows the muco-periosteal flap in process of being raised.



FIGS. 408 AND 409.—PALATAL FLAPS DISSECTED UP AND READY FOR SUTURING.

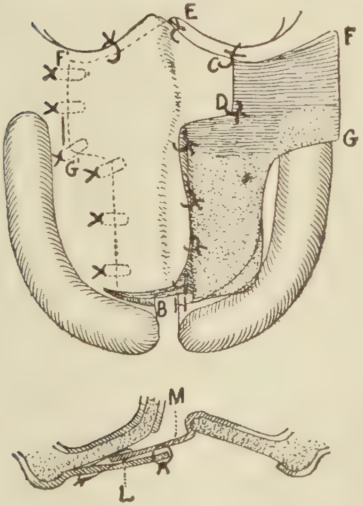


FIG. 410.—PALATAL FLAPS OVERLAPPED AND SUTURED TOGETHER

The lower figure shows the completed palate in section, M representing the flap from the right side, overlapped by and united to L, the muco-periosteum of the left side.

FIGS. 406-410.

LANE'S OPERATION FOR CLEFT PALATE.

of the cleft acting as a hinge. The raw surfaces of these two flaps are approximated by a double row of suitable stitches, and if they unite an effective barrier is produced, constituting a new palate. It will be noted that a considerable area has to be left bare, to be healed by granulation, and some amount of interference with the subsequent development of the teeth may be anticipated. It is very doubtful whether the final results are any more satisfactory than those gained by Langenbeck's operation, and certainly a good many failures and a certain percentage of deaths have been recorded.

Langenbeck's operation of *uranoplasty* is usually undertaken between the age of two and three years, and in practised hands gives admirable results. It consists in the detachment of muco-periosteal flaps from either side, and the careful approximation of their pared edges one to the other. In a case involving both the hard and soft palates there is no reason why the whole cleft should not be dealt with at one sitting; and there are but few cases where the gap is so wide that it cannot be closed by this means, at any rate posteriorly. Occasionally the anterior portion of the cleft has to be left open, especially if the premaxilla has been removed; but this really is not an important matter, as an obturator, carrying the necessary artificial teeth, can always be applied. Where the soft palate, with or without the posterior part of the hard palate, is alone involved, Langenbeck's operation gives admirable results.

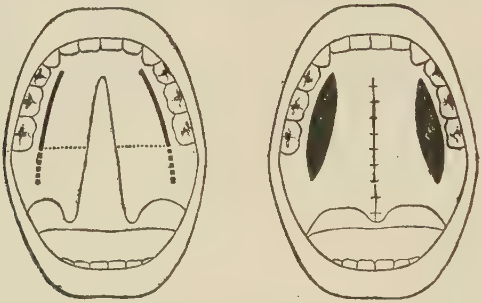


FIG. 411.—DIAGRAMS TO INDICATE EXTENT OF INCISIONS IN URANO PLASTY.

The thick black lines show the primary incision; the thick dotted lines, the extension backwards of the same to relieve lateral tension; the thin dotted lines indicate approximately the position of the free border of the bony palate. The right-hand figure shows the position of the sutures, and the condition of the parts at the close of the operation.

Operation.—Anæsthesia is induced in the ordinary way by chloroform dropped upon a suitable mask or given by Junker's apparatus. The greatest care must be taken not to drop chloroform into the mouth nor to direct the stream of chloroform vapour against the edges of the cleft. The mouth is efficiently gagged open, and preferably by a unilateral instrument which can easily be slipped in and out of place.

Stage I.: Incision and Detachment of Muco-periosteal Flaps.—The knife should be inserted close to the last molar tooth and about half an inch from the alveolar margin, and carried forwards parallel to the teeth to a spot just anterior to the apex of the cleft; or, if the alveolus is involved, the incision should stop behind the lateral incisor to preserve the vascular supply of the front of the flap (Fig. 411). The muco-periosteum is divided down to the bone, and by the use of a suitable raspatory the soft structures of the palate are stripped up towards the middle line, until the point of the instrument is seen protruding into the cleft. Great care is needed to ensure its total detachment from the back of the bony palate, and yet not to damage it at this, its weakest part. This must be thoroughly carried out on both sides. Copious bleeding always accompanies this stage of the operation, and the head should be turned on one side and lowered, and the pharynx kept clear by careful sponging.

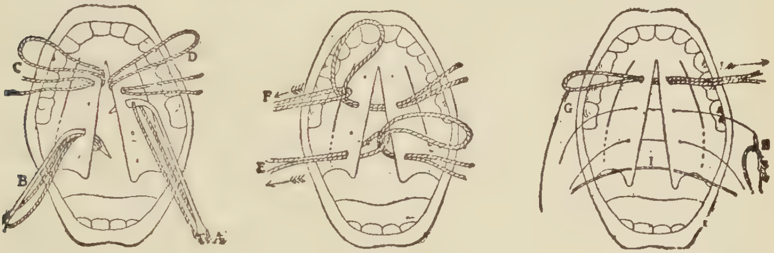


FIG. 412. FIG. 413. FIG. 414.

FIGS. 412-414.—DIAGRAMS TO ILLUSTRATE THE LOOP METHOD OF PASSING STITCHES IN THE OPERATION FOR CLEFT PALATE.

The needles and silk thread are, for purposes of illustration, represented much thicker than would be really employed.

Stage II.: Paring the Edges of the Cleft.—This is accomplished by grasping the base of the uvula with a suitable pair of angular catch-forceps. Thus steadied and held, a thin paring can be removed, in one piece, if possible, on the side seized, and the same process repeated on the other. The paring of the edges is purposely deferred until after the muco-periosteal flaps have been detached, because the freshened edges do not thus get bruised by the frequent use of the sponge; moreover, the bevel at which the edges should be pared can be more accurately estimated when the flaps have been loosened.

Stage III.: Passage and Tightening of Sutures.—The simplest plan to adopt is that known as the 'loop method' of Sir W. Fergusson, and it is carried out as follows: A long-handled palate needle with a suitable curve, and threaded with about 18 inches of fine white silk, is passed through the muco-periosteal flap from below upwards, and at a spot about 2 or 3 mm. from the margin (Fig. 412, A). This loop projecting from the cleft (Fig. 412, B) is now grasped with smooth-nosed forceps, and drawn out of the mouth, whilst the needle is withdrawn. A similar loop is inserted through the opposite side of the cleft at an exactly corresponding point, so that there are now two loops emerging from behind through the cleft (Fig. 412, C, D). One of these is loosely threaded through the other (Fig. 413, E), and the latter gently withdrawn, carrying with it the loop-end of the former (Fig. 413, F), through which a suitable length of fine well-annealed silver wire can be drawn into position (Fig. 414, G, H), and tightened to the requisite degree by a wire-twister, so that the pared edges are exactly apposed. This process is commenced anteriorly and carried backwards until the base of the uvula is reached, the stitches being inserted about half a centimetre apart. Finally, the uvula is stitched with silk inserted by means of a double-curved needle; silver wire would irritate the back of the tongue too much and cause vomiting.

Some surgeons prefer to introduce the wire by means of a specially constructed hollow needle with a double curve, through which the wire is protruded by unwinding a drum in the handle. This is passed through both flaps, commencing at the uvula, and working forwards, tying each stitch as it is inserted.

Stage IV.—It is now only necessary to take steps for the *relief of all lateral tension,* a most important and essential proceeding. The best way to accomplish this is to prolong backwards through the soft palate the lateral incisions already made so as thoroughly to divide the levator palati (see the thick dotted lines in Fig. 411). Occasionally the anterior and posterior pillars of the fauces, containing respectively the palato-glossi and palato-pharyngei muscles, will also need to be snipped across.

The child should be put to bed with the head low, so that any accumulation of blood or mucus may gravitate easily into the pharynx. The mouth can be washed out with a weak solution of sanitas, although some surgeons prefer not to disturb the parts for three or four days. No nourishment should be given for the first four or five hours, and but very sparingly for the first twenty-four. Milk and water, given by a spoon or from a feeder, will form the staple article of diet. By about the fifth day soft food, such as soaked bread and custard pudding, may be safely permitted. The patients are generally allowed up on the sixth day. The silver stitches may be left in for ten days or a fortnight without doing any harm. Should any signs of inflammation occur, the palate should be sprayed over with a solution of peroxide of hydrogen.

In dealing with clefts of the soft palate alone, a modification of the above operation may be performed called *staphylorrhaphy*. The edges are first pared, lateral incisions are then made to divide the levatores palati, and the stitches finally passed and tied.

Results.—It is possible that in most cases articulation will be, if anything, impaired as the immediate result of the operation, since the mechanism which the patient ordinarily employs is thrown out of gear; subsequent education at the hands of a voice-trainer is absolutely essential in order to correct this. Even then the unpleasant articulation occasionally persists, owing to the patient being unable to draw up the velum so as to close the posterior nares; this is due to a reduction of the depth of the soft palate owing to the traction required to close the cleft. In spite of this, however, the operation is most beneficial in that it shuts off the nose from the mouth, prevents the dropping of mucus, improves the sense of taste, and adds greatly to the general comfort of the patient.

Mechanical Treatment of clefts in the palate by means of obturators or artificial vela is still advocated by some surgeons and dentists in preference to any operative interference. An *obturator* consists of an adjustable plate or plug fitted to and closing an aperture in the hard palate. It may be used with advantage in perforations due to traumatism or syphilis, and in apertures left after operations in which portions of the palate are removed, such as excision of the superior maxilla. In cases of double hare-lip and cleft palate, where the os incisivum has been extirpated, an aperture is often left anteriorly which cannot be satisfactorily closed except by an obturator, which also serves to carry the necessary artificial incisors, and may have cheek-plates attached to push forwards the upper lip. For whatever purpose an obturator is needed, it should never take the form of a closely-fitting plug, which, by its constant pressure and irritation, causes the aperture to become enlarged, but always that of a plate, either of thin vulcanite or gold, which can be fixed to the teeth, and maintained in position by suction. It is sometimes found, however, that the addition of an intranasal projection to the upper surface of the plate improves the articulation by diminishing the size of the nasal cavity. An *artificial velum* consists of a plate obturator, to which is attached posteriorly a moveable segment to take the place of the normal velum. Such consists either of a hinged metal plate, resting on the nasal side of the segments of the soft palate, and moved by them, or of a thin india-rubber bag filled with air, sewn to the back of the obturator. They are complicated and difficult to keep in order, and as a general rule the results of operative interference are superior.

Ulceration of the Palate occurs in a variety of forms, *e.g.*, (*a*) *simple*, as an accompaniment of general stomatitis: (*b*) *syphilitic*, which may involve either the hard or soft palate; if superficial, it is usually a late secondary phenomenon; if deep, it involves the bones, and often leads to necrosis, and is then due to tertiary mischief: (*c*) *lupoid*, a somewhat uncommon condition, which may result in great destruction of tissue; it is usually seen in children, and often associated with a similar disease of the nose, from which, indeed, it may have spread: (*d*) *tuberculous*, due to the breaking down of a tuberculous abscess under the periosteum, and then complicated with caries of the bony palate: (*e*) *malignant*, usually resulting from the growth of epithelioma, either starting primarily in the palatal mucous membrane, or extending to it from the tongue, tonsil, or upper jaw.

Acquired Perforations of the Palate, though occasionally caused by traumatism or lupus, are in almost all cases due to tertiary syphilis. The ethmo-vomerine septum is often involved in the destructive process, giving rise to a most offensive discharge from the nose. If the soft palate is alone affected, the velum may become fixed by cicatricial adhesions to the back of the pharynx, and pharyngeal stenosis, or considerable loss of substance of the velum, results. A nasal intonation of the voice is always caused by any condition which interferes with the closure of the naso-pharynx by the velum during articulation. The *treatment* of these conditions should follow the usual antisyphilitic course. Perforations are best remedied by the use of plate obturators. We have seen out-patients make efficient obturators out of a piece of sheet indiarubber maintained *in situ* by suction, or of two pieces stitched together in the middle, one piece passing above and the other below the opening. Occasionally when the aperture is small, the local disease soundly cured, and the general health good, an attempt may be made to close it by stripping up muco-periosteal flaps, paring the edges and suturing them together. The results are, however, seldom satisfactory.

Any of the ordinary forms of inflammation of bone may be met with in the hard palate. **Necrosis** is usually due to tertiary syphilis, or may accompany acute subperiosteal suppuration, extending from an alveolar abscess. In either case the surgeon must wait till the sequestrum is loose, and then it may be removed. **Caries** is generally due to syphilis or tubercle.

The following **tumours** occur on the *hard* palate. Simple *epulis* (p. 798) may extend from the alveolus, or an identical condition may start in the middle line. An *adenoma* of the palatal glands is occasionally met with. It presents as a smooth or papillated tumour, somewhat resembling epithelioma, but distinguished from it by its slower rate of growth, and the absence of ulceration, pain, or glandular enlargement. An operation limited to the soft parts is probably all that is necessary. *Sarcoma* may be primary, and is then often myxo-sarcomatous in type, or secondary. In the former case it simulates rather closely a diffuse alveolar abscess, but is recognised by its slower growth, less pain, absence of inflammation, and, if need be, by the results of an exploratory puncture. *Epithelioma* also occurs, but is uncommon. Treatment for the two latter conditions, if limited to the palate, would consist in partial removal of the affected superior maxilla.

Elongation of the Uvula is frequently the result of a chronic relaxed throat. At first it merely lasts for a time, and by the use of astringents disappears; but later on the elongation becomes chronic, and causes great irritation of the back of the tongue and fauces, resulting in a troublesome throat-cough and even vomiting. Under such circumstances it should be removed. After well cocainizing the part, it is grasped by a pair of hook-forceps, which seize not only the mucous membrane, but also the muscular structures beneath, and a sufficient amount is then removed by snipping it across near the base with a pair of blunt-ended scissors, leaving about a third of an inch of the organ behind.

Affections of the Tonsils.

Acute Tonsillitis results either from cold or from the inhalation of impure air, or of sewer-gas. It is often seen amongst the residents in hospitals (hospital throat), and may precede an attack of acute rheumatism. Three varieties are described:

(*a*) *Acute superficial tonsillitis*, which consists of a slight superficial inflammation, the result of cold, etc., in which the tonsil participates with the pharynx and velum. There is but little swelling of the part, which, however, becomes red and painful, rendering swallowing difficult. Ordinary anti-catarrhal remedies are necessary, and a chlorate of potash gargle.

(*b*) *Acute follicular tonsillitis* is characterized by a general enlargement of the organ, which is dusky red in colour and painful, causing obstruction to both breathing and swallowing, the tonsils, perhaps, almost meeting in the middle line. There is a good deal of yellow patchy exudation from the follicles, which may coagulate on the surface and form a false membrane, somewhat like that of diphtheria. The temperature is high; the glands below the angle of the jaw become enlarged and tender, and may suppurate; the tongue is covered with a thick, whitish fur, and the bowels are confined. Such a condition is often due to streptococci, and may herald in an attack of septicæmia.

(*c*) *Acute suppurative tonsillitis*, or *quinsy*, is an acute inflammation of the tonsil, with suppuration within and around it (*peritonsillar abscess*). Both sides are affected, but the suppuration is often unilateral, or if bilateral, one tonsil is affected before the other; pus usually takes three to seven days to form. The swelling is great, so that breathing and swallowing are alike difficult; the temperature is high, pain is severe, and the cervical glands are considerably enlarged. Œdema of the glottis may result. Other symptoms are much the same as in the above. Left to itself, the abscess sooner or later bursts and gives the patient immediate relief.

The **Diagnosis** must be made from *scarlet fever* by the absence of the characteristic rash and red tongue of the latter condition, and by the redness being more dusky and less diffuse in tonsillitis. From *erysipelas of the fauces*, it is known by the redness being more concentrated, the œdema less marked and more limited, by the glands at the angle of the jaw being less enlarged, and by the absence of any external manifestation of the disease. From *diphtheria* the follicular variety is recognised by the want of adhesion of the false membrane to the subjacent parts, it being readily detached by a camel's-hair brush, and by the absence of the Klebs-Löffler bacillus on cultivation (p. 133).

Treatment should always be commenced by a good calomel purge, which may be followed by the administration either of salicylate of soda (20 grains, thrice daily), or of chlorate of potash and sulphate of magnesia, to which a few drops of tincture of aconite may be added if the constitutional symptoms are severe. The patient will experience much relief by inhaling the steam from hot water (150° F.), in which a little creasote or carbolic acid is dissolved, or the tonsils may be scarified. Suppuration is dealt with by a free incision, the knife entering at a spot on the line drawn from the base of the uvula to the last molar tooth, and nearer the inner than the outer end

(Fig. 415, X), as recommended by Sir St. Clair Thomson. Hot flannels or fomentations may be applied to the neck and throat, and plenty of fluid nourishment administered. This is followed as soon as possible by iron, bark, and other tonics. The fact that quinsy is very liable to recur suggests that during the quiescent interval after an attack the tonsils should be removed.

Chronic Tonsillitis appears in two distinct forms:

(*a*) *Chronic inflammatory tonsillitis* occurs in children whose tonsils, after one acute attack, remain enlarged, painful, congested, and very liable to recurrence, which often runs on to suppuration and ulceration. After a time the tonsils shrink back and atrophy, becoming hard and fibroid.

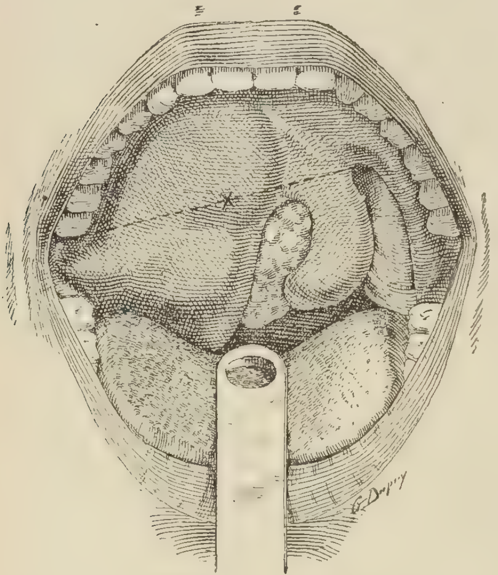


Fig. 415.—Diagram to indicate the Situation to Open a Peritonsillar Abscess—viz., on a Line drawn from the Base of the Uvula to the Last Molar Tooth, but Nearer the Uvula. (After Sir St. Clair Thomson.)

(*b*) *Chronic hypertrophic tonsillitis* is met with in weakly children predisposed to tubercle, and is usually associated with the presence of adenoids in the naso-pharynx. The tonsils are enlarged, pale in colour, and firm in consistence; the orifices of the crypts are often patent, and in them are seen plugs of mucous secretion, which may become infiltrated with lime salts, forming concretions (tonsilloliths), or may develop into cysts. Sometimes the tonsils project inwards, and may meet in the middle line beneath the uvula, causing obstruction both to swallowing and respiration; sometimes they are buried and lie under cover of the anterior pillar of the fauces, but their enlargement may be recognised by pressing inwards from the neck. The patient usually breathes with the mouth open, owing to the concurrent naso-pharyngeal obstruction, and from the same cause speaks thickly, as if he had some loose body in the mouth, and necessarily snores during sleep. Hearing is often interfered with from the mucous lining of the Eustachian tube becoming thickened and inflamed. Recurrent attacks of inflammation occur from time to time, with or without suppuration.

The **Treatment** of these cases consists in first attending to constitutional weakness by removal of the patient to fresh or seaside air, and by the administration of iron and cod-liver oil; at the same time the throat should be painted twice a day with glycerine of tannic acid, or with equal parts of glycerine and tinct. ferri perchloridi. Failing this, the tonsils should be removed, and for choice by enucleation.

Tonsillotomy may be undertaken in the following ways:

(*a*) *By the guillotine.* The fauces having been carefully and repeatedly brushed or sprayed with a 5 per cent. solution of cocaine, the mouth is opened and one of the many forms of tonsil guillotine introduced; Mackenzie's spade guillotine is as good as any. The ring of the instrument is passed over the projecting organ, external pressure behind the angle of the jaw assisting in this manœuvre. By the pressure of the thumb the projecting mass is cut off by the sharp blade. In dealing with the right side, unless the surgeon is ambidextrous, he had better stand behind the patient's head, looking over into the mouth.

(*b*) *By the bistoury.* The tonsil is seized at its lowest point and drawn well inwards by means of hooked forceps, and the projecting mass removed by a straight blunt-ended bistoury, the base of the blade being guarded, if preferred, by a piece of plaster wrapped round it. The incision should be made from below upwards, and the edge of the knife kept rather in than out, so as to avoid all risk of wounding the internal carotid, which is in close contiguity to the outer surface of the gland. Care must be taken to include the lowest portion of the tonsil, which often hangs down into the pharynx, and is liable to be left behind. This method is not frequently employed at the present day.

(*c*) In children the hypertrophic type of enlarged tonsil may be *enucleated* without much difficulty by dividing the mucous membrane in front of it, and shelling it out of its bed, the posterior reflection of mucous membrane being subsequently divided by bistoury, scissors or guillotine.

The hæmorrhage, though brisk for the moment, soon ceases if care is taken not to cut too deeply, or encroach upon the surrounding mucous membrane. Should the bleeding continue, it can generally be arrested by douching the face with iced water, or by the local pressure of wool pledgets soaked in iced boric acid lotion, or in adrenalin. Occasionally a bleeding vessel can be seen and secured by ligature; but in bad cases of persistent or recurrent bleeding it may be necessary to stitch the anterior and posterior pillars of the fauces together over a gauze plug which is retained for twenty-four hours. Serious bleeding is more likely to occur in adults than in children.

Syphilitic Disease of the Tonsil is met with in various stages. The *primary chancre* is seen occasionally, arising in one case we know of through infection from a stick of caustic which had been previously used to cauterize a syphilitic ulcer and insufficiently cleaned before being applied to the tonsil, the surface of which was abraded. The glandular enlargement in the neck is very marked in such cases, and the course of the disease as a rule severe. *Secondary ulcers* of the 'snail-track' type (*plaques muqueuses*) are common in this region, being usually symmetrical. In the tertiary period a *diffuse gummatous infiltration* occurs, involving also the palate and fauces (p. 864) and leading to pharyngeal stenosis.

Tumours of the Tonsil are almost always malignant in type, but are not very common. *Epithelioma* occurs as a firm indurated infiltration, rapidly spreading to adjacent parts, and involving the lymphatic glands. It generally starts either in the root of the tongue or in the pillars of the fauces, and presents a ragged ulcerated surface with a hard margin and sloughing base. It is not always very painful, and notice may first be called to it by the enlargement of the glands in the neck. It runs a rapidly fatal course, if left to itself. *Lympho-sarcoma* of the tonsil arises in the organ itself; it presents a smooth, dusky red appearance, the mucous membrane being stretched over it, and feels soft and almost fluctuating. In the early stages it may be freely moveable, but ere long it infiltrates surrounding structures, and affects the neighbouring lymphatic glands. *Round-celled sarcoma* also attacks the tonsil as a primary growth, and is less limited and defined than the former. In all these varieties the growth extends into the pharynx, impeding deglutition and respiration, and ulceration with or without serious hæmorrhages may ensue; indeed, the latter complication is a frequent cause of the fatal result.

Extirpation of Malignant Tumours of the tonsil is often impracticable from the extent of the disease and the early implication of the surrounding structures, although it has now been shown that they are more amenable to treatment than was formerly thought to be the case. The disease may be dealt with in two ways: (*a*) *From the mouth* in the case of the loosely encapsuled and freely moveable lympho-sarcomata. The capsule is divided preferably by a galvano-cautery, and the growth shelled out sometimes with the utmost ease, and with very little hæmorrhage. Recurrence in the lymphatic glands is, however, almost certain to follow. (*b*) *From the neck.* This is the only plan of any value in dealing with an epithelioma, and it is seldom available, owing to the extent of the mischief when the patient is first seen. An incision is made along the anterior border of the sterno-mastoid, and a careful dissection conducted down to the pharyngeal wall, removing all lymphatic glands which are enlarged or suspicious, and securing the external carotid or its anterior branches. The mass is then isolated from the surrounding structures and removed. It is sometimes necessary to make an incision from the angle of the mouth backwards through the cheek, or to remove a portion of the mandible. It is very questionable whether extensive proceedings such as these are ever justifiable. The immediate mortality is high, and the ultimate freedom from recurrence very small. The majority of cases demand merely palliative treatment, including gastrostomy to permit of the administration of food, and tracheotomy.

Affections of the Pharynx.

Acute Pharyngitis is usually associated with a similar inflammatory condition of the velum palati, nasal mucous membrane, and tonsils, and results from exposure to cold, from absorption of sewer-gas, and from general diseases of the exanthematous type—*e.g.*, scarlet fever and diphtheria. It is characterized by redness, pain, and swelling of the mucous membrane, which becomes covered with mucus or muco-pus. An irritable cough, with perhaps sneezing, interference with nasal respiration, and great pain on swallowing, are produced by this condition, and if it spreads to the Eustachian tube temporary deafness is induced. Ulceration of the velum and fauces occasionally follows.

The **Treatment** consists in attending to the general condition, especially if of exanthematous origin, and when due to catarrh, in administering antiphlogistic remedies (*e.g.*, purgatives, sudorifics, and diuretics) and soothing local applications (*e.g.*, ice to suck, chlorate of potash gargle, etc.). Great relief is often given by inhaling steam from water at 150° F. to which a little Friar's balsam has been added.

Chronic Pharyngitis is commonly met with in clergymen and public speakers who are called upon to exert their voices for any length of time, in costers and street-hawkers who shout their wares, and in drinkers and smokers. It may commence as a chronic inflammation, or may follow an acute attack. The mucous membrane is more or less red and infiltrated, with vessels coursing over it, and there is often a good deal of muco-purulent discharge. If the buccal side of the velum palati is affected, there is usually much less secretion than from the pharyngeal aspect, where a considerable amount of dark green viscid material may collect and cling to the pharyngeal wall, constituting scabs, which may decompose and cause the breath to be somewhat offensive. Two main varieties are described:

1. *Chronic follicular pharyngitis*, in which the lymphoid follicles scattered throughout the mucous membrane become enlarged. This is specially evident upon the soft palate, but is often greater in amount upon the upper wall and sides of the pharynx, where there is a mass of lymphoid tissue, sometimes known as the *pharyngeal or Luschka's tonsil* (*vide* Adenoids, p. 827). The uvula may be also elongated and hypertrophic in this condition.

2. *Chronic atrophic pharyngitis* is generally associated with the atrophic form of rhinitis sicca (p. 820), and possibly with chronic laryngitis. The mucous membrane is smooth, dry, and glazed, and the exudation forms adherent scabs. The throat feels dry and irritable, and the voice is often husky.

The **Treatment** of chronic pharyngitis varies with the condition and character of the affection. In many cases the nasal trouble is the more urgent, and if it is treated effectively the pharynx improves rapidly. In simple relaxed throats all sources of irritation—such as smoking, spirits and condiments—must be avoided, the bowels and digestion attended to, and astringent sprays, gargles, or applications made use of. The most useful reagents are the glycerine of tannic acid, and equal parts of glycerine and tinct. ferri perchloridi, whilst chloride of ammonium inhalations are sometimes valuable, as also sprays of menthol dissolved in paroleine, or lozenges containing menthol and liquorice. When the inflammation is of the follicular type, it may be further necessary to destroy the follicles with the galvano-cautery after cocainizing the surface; enlarged and varicose vessels may be divided in the same way.

Syphilitic Affections of the Pharynx may be met with in the secondary or tertiary stages. In the former they are of a superficial character, such as mucous tubercles, snail-track ulcers, etc.; in the latter they appear in the shape of a *diffuse gummatous infiltration*, which is often of considerable consequence, both at the time and subsequently. It manifests itself as a widespread nodular thickening of the mucous membrane, especially in the neighbourhood of the fauces and soft palate, which rapidly runs on to ulceration, and may impede both respiration and deglutition. The administration of salvarsan, or of mercury and iodide of potassium usually causes a rapid improvement, but the subsequent cicatrization may bind down the velum, and lead to pharyngeal stenosis of such a character as to constitute a fibro-cicatricial septum, with an opening through it perhaps only large enough to allow a small bougie to pass. For such a condition much may be done; the opening may be more or less dilated by careful division of some of the bands and the passage of bougies; and the soft palate can be set free from the dorsum of the tongue. Of course, there is a great tendency for the opening to contract again, and treatment by bougies must be persisted in.

A *localized gumma* may form in the submucous tissue, not unfrequently involving the posterior pharyngeal wall, and running its ordinary course with or without ulceration.

Tumours of the pharynx are rarely primary. They may extend into it, however, from surrounding parts—*e.g.*, naso-pharyngeal polypi arising from the base of the skull, or retro-pharyngeal growths from the spine.

Epithelioma either involves the pharynx primarily, or spreads to it from adjacent parts, such as the tongue or tonsil. The usual type of tumour develops with some amount of ulceration; lymphatic glands become secondarily affected, and the tumour gradually invades surrounding tissues, although it is interesting to note that for some time it is limited to the mucous membrane, extending superficially over it, but not involving the underlying pharyngeal muscles. Death results from hæmorrhage due to ulceration into large vessels, from interference with swallowing or breathing, from pressure on important nerves, or from general dissemination.

Treatment.—It is only within the last decade that any attempt has been made to deal with these cases; even now the mortality is very high, and statistics prove that if the operation involves removal of portions of the upper or lower jaw, a fatal issue is likely to follow.

The same precautions as to cleansing the teeth, etc., must be taken as in dealing with naso-pharyngeal or buccal growths. As a general rule, an incision along the anterior border of the sterno-mastoid is the best to employ, although occasionally a second may be required, splitting the cheek towards the angle of the jaw. The external carotid is tied, all glands are removed, and then the growth is extirpated, partly from without, partly from within. It is always advisable to perform a preliminary tracheotomy, and feeding must be undertaken for some days by means of a stomach-tube. Transhyoid pharyngotomy is a useful means of approach in some of these cases (p. 907).

Retro-pharyngeal Abscess is acute or chronic in its course. The *acute* form results from infection through the mucous membrane, as by fishbones, etc.; or arises from an inflammation of the lymphatic glands which are found in this situation in children, but atrophy in adults, and derive their lymph from the interior of the nose and naso-pharynx. The pus is situated between the pharyngeal wall and the pre-vertebral fascia, and is therefore tolerably superficial. The *chronic* variety generally follows tuberculous caries of the spine, or disease of the bones at the base of the skull, and the pus is placed behind the pre-vertebral fascia. Whether acute or chronic, the abscess forms a tense elastic swelling, situated behind the posterior pharyngeal wall; in the former case it is associated with high fever, and locally much redness and inflammatory œdema, which may even extend to the glottis, and cause dyspnœa; in the latter, where the affection is chronic, there is less local inflammatory reaction, but signs of cervical spinal disease are present. The abscess may burst into the pharynx, or may burrow outwards on either side, being guided by the pre-vertebral fascia, and point either in front of or behind the sterno-mastoid.

Treatment should never be delayed, from fear of the supervention of œdema of the glottis. The *chronic* abscess should always be opened from the neck, as then an aseptic course can be maintained, and there is no fear that the pus will enter the air-passages. If pointing in front of the sterno-mastoid, the abscess is opened in that situation; but otherwise an incision should be made along the posterior border of the muscle, which must be drawn forwards, and the transverse processes of the cervical vertebræ defined. Possibly the abscess will be opened by the necessary manipulation of the wound; if not, the index finger of the left hand should be placed against the abscess wall in the mouth to guard it from injury, and a pair of sinus forceps thrust into it in front of the vertebræ by the right hand. A drainage-tube is then inserted, and the case runs an ordinary aseptic course.

The great majority of cases of *acute* abscess, however, may be opened from the mouth without much fear. The child is placed on its back with its head hanging far back; a gag is introduced, and a guarded knife inserted through the mucous membrane into the swelling at its most prominent point. Careful swabbing should avoid any danger of pulmonary trouble.

Affections of the Œsophagus.

The œsophagus reaches from the lower extremity of the pharynx to the cardiac orifice of the stomach, a distance of about 10 inches; it corresponds above to the lower border of the cricoid cartilage, and below approximately to the lower end of the sternum. The distance from the central incisor teeth to the stomach is about 16 inches. The tube is not quite in the middle line, but inclines to the left as it passes through the posterior mediastinum. The pericardium is in relationship with the œsophagus in front, and the pleura on each side. Its narrowest portions are its upper end, in the centre about 12 inches from the teeth where the left bronchus crosses it, and at the cardiac extremity. The pneumogastric nerves are also in immediate relationship with it.

The **Methods of Examination** of the œsophagus are threefold:

1. By the introduction of a *bougie* it is possible to detect the existence of a stricture and its situation. Before undertaking this, it is essential to make sure that there is no aneurism of the aorta by the use of radiography or by auscultating the left vertebral curve. To pass an œsophageal bougie, the surgeon stands in front and slightly to the right of the patient, who is seated with the head held forward; if thrown backwards, the larynx is pressed against the spine, and the difficulty of introducing the instrument is increased. The bougie, which by preference should have a conical end, is warmed and smeared with glycerine or melted butter, and, having been suitably curved, it is guided by the surgeon's left index finger over the base of the tongue and epiglottis into the œsophagus. This stage usually causes a certain amount of discomfort and retching on the part of the patient. Once past the entrance to the larynx, the bougie is pushed steadily onwards, and if there is no stricture, the point enters the stomach about 16 inches from the teeth. Formerly this was the only method of examination available for the lower part of the tube. It was possible to palpate in an indefinite way the upper part of the tube, and auscultation of the vertebral curve whilst the patient swallowed, was sometimes resorted to; but obviously these methods are very inexact.

2. The use of the **œsophagoscope** has transformed the surgery of this organ. The instrument is practically the same as that introduced by Killian for examination of the bronchi (p. 900), and its method of use is very similar. It is advisable to administer a preliminary injection of morphia and atropin not only to dull the patient's sensitiveness, but also to check the salivary secretion. The mouth and pharynx are thoroughly cocainized, and then, with the patient either sitting or lying on his back, it is possible to introduce the instrument and gently to insinuate it down the tube. By this means foreign bodies, growths, strictures, etc., can be seen, and direct treatment controlled by vision can then be adopted.

3. **Radiography** is also of assistance in the examination of the œsophagus. Metallic foreign bodies can be seen and accurately located; and by the use of a bismuth meal it is possible to determine the situation of a stricture, and the amount of distension of the œsophagus above it.

Malformations of the œsophagus are congenital or acquired.

A **Congenital** communication may exist between the œsophagus and trachea, either in the form of a small fistula, or the upper end of the œsophagus ends blindly, whilst the lower end opens into the trachea near its bifurcation. Life is impossible under such conditions, and the children die shortly after birth. Congenital stricture may also be met with near the cardiac orifice, resulting in general distension and dilatation of the œsophagus (*œsophagocœle*). The **Acquired** malformations consist in the development of the so-called *Diverticula*. Two forms have been described by Zenker; (*a*) *Pressure*

Diverticula, which are the more common, and seem to be associated with some congenital weakness of the wall, probably connected with the branchial clefts. They vary much in size, perhaps becoming as large as a child's head, and rarely come under observation before the age of thirty. They usually spring from the posterior wall, close to the junction of the pharynx and œsophagus, constituting what is sometimes known as a ' pharyngocœle '; the cavity extends downwards between the œsophagus and vertebral column. The *symptoms* are due to distension of the cavity with food which stagnates and putrefies, forming a swelling in the neck which can be emptied by pressure; the difficulty of obtaining sufficient food gradually leads to emaciation. When a bougie is used, it generally passes into the diverticulum, and hence its onward course is arrested; by careful manipulation it may be kept on the sound wall, and so slipped past the orifice into the stomach. The administration of a small bismuth meal and subsequent radiography will probably make clear the diagnosis. *Treatment*, where possible, consists in exposing the diverticulum in the neck, through a lateral incision in front of the sterno-mastoid, removing it, and stitching up the opening in the pharyngeal or œsophageal wall. (*b*) *Traction Diverticula* are much rarer; they usually occur on the anterior wall, near the bifurcation of the trachea, and are due to cicatricial traction from without, as by an inflamed bronchial gland. They are always of small size, often multiple, and cause no symptoms, unless a foreign body lodges in them, when ulceration and perforation may lead to suppurative mediastinitis and death. They cannot be recognised *ante mortem*, except, perhaps, by direct œsophagoscopy.

Foreign Bodies not unfrequently lodge in the œsophagus, especially in children and lunatics. Portions of food, coins, fishbones, pins, plates of false teeth, etc., are the substances usually met with. The patient complains that something has lodged in the gullet, causing a feeling of pain and distension, whilst swallowing is painful or impossible, and respiration may be more or less hampered. Large bodies are often impacted at the entrance to the gullet, and then cause sudden death from dyspnœa; if the obstruction is not so great and remains unrelieved, œdema of the glottis may supervene. Impaction lower down is likely to be followed by ulceration, perforation, and death, either from hæmorrhage owing to one of the large vessels being opened, or from suppurative cellulitis. In the case of a metallic body, diagnosis both as to its presence and situation can be made by radiography, and attempts at removal undertaken with the assistance of the radiographic screen. By means of the œsophagoscope it is possible to see the foreign body and sometimes to remove it.

The **Treatment** varies much according to the nature, size, and situation of the obstructing body. If small and incapable of being detected by a sound—*e.g.*, a fishbone—it is best removed by an expanding probang (Fig. 416), being caught in the loops of thick horsehair forming part of the apparatus. If a coin or small hard substance is impacted, it may be removed by œsophageal forceps, or by a coin-catcher. If it is impossible to draw it up, it may sometimes be pushed down into the stomach. A large bolus of food may be removed by forceps from the upper part of the œsophagus, and large foreign bodies—*e.g.*, plates of teeth—may be similarly extracted, perhaps with the help of the œsophagoscope, though great care must be taken not to tear the mucous membrane.

If firmly impacted in the upper part, *œsophagotomy* may be performed. An incision, 4 inches long, is made along the anterior border of the sterno-mastoid, preferably on the left side, because the œsophagus naturally curves that way. The surgeon carefully finds his way between the carotid sheath on the outer side and the larynx and trachea on the inner, avoiding the thyroid vessels and nerves. The projection of the foreign body will indicate the situation of the tube, and this is incised and the obstruction dealt with. The œsophageal wound may then be closed by sutures which do not include the mucous membrane, whilst the external wound is either packed with gauze plugs or drained. When the foreign body is located in the upper part of the thoracic portion of the œsophagus, the tube is opened as low as possible by cutting down on the point of a bougie passed from the mouth, and then it is often possible to extricate it.

When impacted in the thorax and removal by one of the suggested methods is impossible, it has been proposed to open the œsophagus from behind in the posterior mediastinum, after excising the necks of one or more ribs; but a successful case has not yet been published.

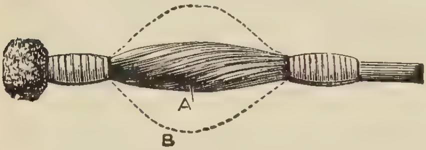


FIG. 416.—EXPANDING PROBANG FOR THE REMOVAL OF FOREIGN BODIES FROM THE ŒSOPHAGUS.

It is introduced closed as at A, and opened as at B on withdrawal.

When the foreign body is fixed near the cardiac orifice, and cannot be moved either up or down, the stomach may be opened, the fingers or even the hand inserted into it, the cardiac orifice dilated, and the obstruction removed.

When once the foreign body has passed into the stomach, purgatives and emetics should be avoided, and if not of large size and irregular shape, the case is left to Nature, the treatment being merely expectant. The patient is kept quiet, and fed on pultaceous food—such as brown bread, porridge, etc.—and the course of the foreign body watched by radiography. Should it be large and its course be arrested at any particular point, and especially if inflammatory symptoms occur, a laparotomy for its removal must be promptly undertaken.

Inflammation of the œsophagus, with or without ulceration, is caused by swallowing corrosives or irritants, and, in a more localized form, by the impaction of foreign bodies. The symptoms are pain and difficulty in deglutition, and the treatment consists in the restriction of the diet to liquids, whilst in bad cases rectal feeding may be necessary. Chronic catarrh, followed by stenosis, may result from the continual drinking of raw spirits.

Varix of the veins in the lower portion of the œsophagus is occasionally met with as the result of pressure on the portal vein, or from cirrhosis of the liver. This is due to the fact that these branches open into the gastric division of the portal system, passing through the œsophageal opening in the diaphragm. Hæmatemesis may result, and has even proved fatal.

Spasm of the Œsophagus, or hysterical stricture, arises in neurotic young women, usually under twenty-five years of age, and, although sometimes independent of organic lesion, is often associated with some slight abrasion or ulceration of the mucous membrane, perhaps originated by the impaction at an earlier date of a fishbone. The symptoms complained of are difficulty in swallowing, and a sensation as of a ball arising in the throat (*globus hystericus*), due to a spasmodic action of the pharyngeal constrictor muscles. At times, when the patient's attention is diverted, deglutition occurs quite normally. The best course of *treatment* is anti-neurotic in character (*e.g.*, cold douches to the spine, massage, the administration of purgatives, valerian, etc.), whilst the passage of a full-sized œsophageal bougie is useful.

Organic Stricture of the Œsophagus occurs in two forms—the fibrous and the malignant:

1. *Fibrous Stricture of the Œsophagus* is usually located near its commencement, just behind the cricoid cartilage, and is most frequently caused by the swallowing of corrosives, and the cicatrization of the wounds caused thereby; it also results from syphilitic disease. At the cardiac orifice it may arise from the healing and contraction of a gastric ulcer. The main *symptom* produced is a gradually increasing difficulty in the swallowing, firstly of solids, but finally even of fluids. If the obstruction is placed at the upper end of the tube, food is returned immediately; but if lower down, the œsophagus may become dilated, and in this pouch or œsophagocœle the food collects for a time, and then returns unchanged. There is but little pain in this form of stricture, although the patient is usually able to indicate the level of the obstruction. As the case progresses, he becomes steadily emaciated from sheer starvation, and may even die from this cause.

2. *Malignant Stricture of the Œsophagus* is usually epitheliomatous in type, occurring in subjects over forty years of age, and situated either at the junction of the pharynx and œsophagus, *i.e.*, behind the cricoid cartilage (Fig. 417), or in the middle of the tube, where it is crossed by the left bronchus, or at the cardiac orifice of the stomach; in the latter site, columnar carcinoma is the form usually found. The growth involves the whole circumference of the tube, and sooner or later ulcerates, perhaps perforating the trachea, pleural cavity, or one of the large vessels. Secondary deposits occur in the lymphatic

glands, either of the neck or posterior mediastinum, visceral complications being uncommon. The *symptoms* are similar in character to those of fibrous stenosis detailed above, but in addition the vomited materials may contain blood, and there is a good deal of cough and pain, referred usually to the site of the disease. Should the growth be at the upper end of the tube, a tumour may be distinctly felt, placed deeply in the neck and more marked on the left side; in the earlier stages nothing can be felt externally, although the side-to-side movements of the larynx may be impeded. Perforation of the trachea leads to the entrance of food into the air-passages, and rapidly results in septic pneumonia and death. When the upper part of the gullet is affected, the growth may spread to the back of the larynx, and cause hoarseness and even aphonia. Occasionally the pneumogastric nerves may be involved in the mass, leading to interference with the action of the heart, whilst implication of the recurrent laryngeal nerves causes constant cough and uni- or bilateral paralysis of the larynx.

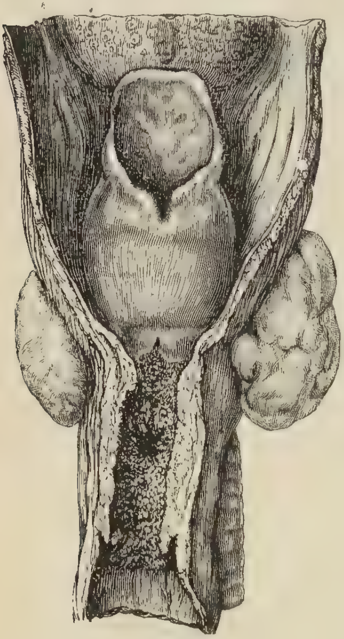


FIG. 417.—CANCEROUS GROWTH OF THE ŒSOPHAGUS. (TREVES' 'SURGERY.')

The *Diagnosis* of œsophageal stricture can be made by the administration of a bismuth meal and radiography, or by examining the condition of the tube with an œsophageal bougie. The greatest care must be taken, especially in suspected malignant disease, as it is not difficult to perforate the walls and open up the mediastinal tissues, causing thereby a fatal cellulitis. A cancerous stricture sometimes feels rough and is painful; a simple stricture is smooth, regular, and almost painless. It is by no means easy to distinguish the two forms by the bougie alone, and the history of the case and the general condition of the patient will need to be investigated thoroughly; a hacking cough with no special pulmonary symptoms is always a bad and suggestive sign. The use of the œsophagoscope in skilful hands will enable the upper surface of the stricture to be seen, and an absolute diagnosis effected.

Treatment of Fibrous Stricture of the Œsophagus.—(*a*) Dilatation of the stricture by means of gradually increasing bougies; for this purpose it is better to use conical rather than blunt-ended instruments. The use of the œsophagoscope facilitates this procedure. An interval of some days should elapse between the attempts at dilatation, and during this period the patient should be given as much food as he can take in the shape of strong broths, minced meat, raw eggs, etc., or, if need be, rectal alimentation must be resorted to. (*b*) If it is impossible to dilate, or if the stricture recurs, a fine rubber tube can usually be passed through the stricture by the assistance of the œsophagoscope, and is maintained there for a time. The upper end is drawn out of the mouth and fixed to the ear. Feeding is thereby rendered easy, and the presence of the tube for a time gradually determines dilatation of the stricture. (*c*) When the contraction is at the pharyngeal extremity, it may be possible to divide, and subsequently dilate, the stricture by the aid of the œsophagoscope. (*d*) If the cardiac orifice of the stomach is contracted, the stomach may be opened as in gastrotomy, and the fingers used to dilate the stricture (retrograde dilatation). (*e*) Where these proceedings are not possible, or, if tried, have failed, the stomach may be opened and division of the stricture by Abbé's *string saw* attempted. The patient is made to swallow one end of a piece of string, or a small shot may be clamped on a piece of fine silk, and allowed to find its way into the stomach. When this viscus is opened, the free end is secured, and by this means a coarse silk thread is carried through the obstruction; by up-and-down sawing movements the stricture can be thereby divided, enabling the surgeon to introduce bougies. Excellent results have been reported from such practice. (*f*) *Gastrostomy* (p. 1005) is the final resource. Occasionally when the œsophagus has by this means been kept at rest for some time, the stricture will yield, and dilatation by bougies becomes practicable. In such a case the opening in the stomach may be allowed to close.

Treatment of Malignant Disease of the Œsophagus.—Dilatation by bougies even with the assistance of the œsophagoscope, should not be employed as a routine practice, for fear of increasing the ulceration, causing severe hæmorrhage, or perforating the walls of the tube. It may, however, be used very carefully so as to enable a tube to be passed through the stricture for feeding purposes. Symond's method of *tubage* may be utilized in malignant disease, the patients often bearing the inserted tube well, even when the cardiac orifice is involved, the lower end then projecting into the cavity of the stomach. Radium has been employed, but is of little real value, for although the primary growth may be improved, the patient dies of secondary deposits which cannot be affected by its influence. Hence, *gastrostomy* is likely to be required sooner or later in not a few of the cases.

By the term **Dysphagia** is meant a condition in which swallowing is painful or difficult. The **Causes** are very numerous, and may be arranged as follows:

1. *Pharyngeal—e.g.*, acute or chronic inflammation, whether simple, scarlatinal, diphtheritic, etc.; ulceration of syphilitic or malignant origin; stenosis as a result of ulceration; paralysis (*e.g.*, labio-glosso-laryngeal or bulbar) or spasm; impaction of foreign bodies; naso-pharyngeal polypi projecting behind the velum; retro-pharyngeal abscess or tumour, etc.

2. *Laryngeal—e.g.*, acute or chronic laryngitis; tuberculous, syphilitic, or malignant disease.

3. *Œsophageal—e.g.*, acute or chronic inflammation, impaction of foreign bodies, the presence of diverticula, œsophagospasm, and simple or malignant stricture.

4. *Extrinsic.*—In the *neck :* goitre, enlarged glands, aneurisms, etc. In the *thorax :* mediastinal growths or glands, aneurisms of the aorta and large vessels, tumours growing from the vertebral bodies, pericardial effusion, and displacement backwards of the sternal end of the clavicle.

To *investigate a case of dysphagia*, note: (1) The method of onset, whether acute or chronic—if the former, it is probably due to a foreign body; (2) the condition of the pharynx as seen from the mouth and on digital exploration; (3) the condition of the neck as seen and felt from without, whether or not a tumour is to be felt behind the cricoid, or whether a goitre or aneurism exists; (4) the character of the voice, as indicative or not of laryngeal mischief—if the voice is husky, a laryngoscopic examination must be made; (5) the chest must be carefully examined for aneurisms, etc.; (6) the œsophagus is examined by bougies or the œsophagoscope. If the obstruction is in the œsophagus, the patient's age and general condition will give *prima facie* evidence as to whether or not it is due to malignant disease; but it must not be forgotten that the stenosis *per se* causes some of the loss of flesh and of weight. The presence of blood and offensive mucus on the bougie or on the material vomited, and the existence of enlarged glands in the neck, will also assist in establishing a diagnosis.

CHAPTER XXXI.

AFFECTIONS OF THE EAR.

THE **Examination of the Ear** is carried out by inspecting the membrana tympani through a speculum by means of light reflected from a frontal mirror; by testing the power of hearing; and by ascertaining whether or not the Eustachian tube is permeable, and the effect on the hearing of inflation through this channel.

1. **Visual Inspection** by means of a speculum and frontal mirror. In introducing the speculum the auricle is held between the third and fourth fingers of the operator (the left hand being used for the right ear, and *vice versa*) and drawn backwards, upwards, and outwards so as to straighten the cartilaginous portion of the meatus. The speculum held by the operator's thumb and first finger is then gently inserted and held in position. The reflected light illuminates the tympanic membrane, unless the presence of wax, epithelial débris, or pus obstructs the view, when they must be removed by cotton-wool mops or by syringing. The following points are to be noted in the normal membrana tympani (Fig. 419): The projection of the short process and handle of the malleus which runs from the centre upwards and forwards; behind this the processus gracilis of the incus and the tendon of the stapedius; and at the upper border Shrapnell's membrane (Fig. 421). The motility of the membrane should be considered, as also its colour, whilst pathologically the presence of perforations, polypi, or adhesions, should be noted.

FIG. 418.—EUSTACHIAN CATHETER.

2. The **Investigation of the Hearing** is usually carried out by testing the greatest distance at which the patient can hear the ordinary conversational voice or the tick of a watch; the whispered voice is also an important test.

The cause and location of deafness is ascertained by **Rinne's Tuning-Fork Test.** To perform it a tuning-fork of about five hundred and twelve vibrations is placed in contact with the mastoid process, and retained there until the patient can hear it no longer. If now it is placed opposite the external auditory meatus, the sound should again be heard if the middle ear is normal, but will not be noted if disease is present. **Weber's Test** consists in placing a vibrating tuning-fork in the middle line of the forehead. In cases of pure middle-ear disease, the sound will be noticed more in the affected ear than on the healthy side.

3. **Inflation of the Tympanic Cavity** is required both as a test of the permeability of the Eustachian tube and also as a means of treatment in various conditions. The methods of effecting it are as follows:

Valsalva's Method consists in closing the lips, holding the nose, and expiring forcibly; the air is thereby driven up the Eustachian tubes if they are patent.

In **Politzer's Method** an indiarubber bag with a teat-like end is introduced into one nostril so as to occupy it completely. The other nostril is closed by the surgeon's finger. The patient is instructed to take a sip of water and to hold it in the mouth with closed lips until told to swallow. As he swallows, the bag is forcibly compressed, and air is thereby driven up the tubes. An auscultating tube may pass from the patient's meatus to the surgeon's ear, and various sounds, whistling, bubbling, etc., may be detected, according to the character of the lesion.

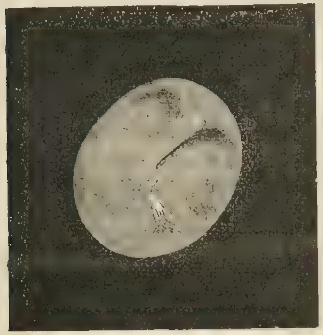


FIG. 419.

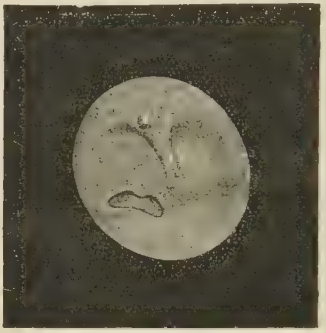


FIG. 420.

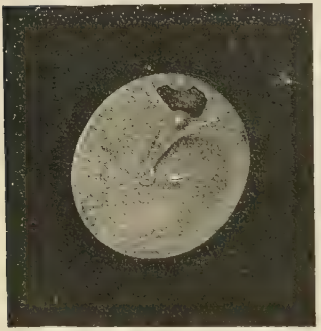


FIG. 421.

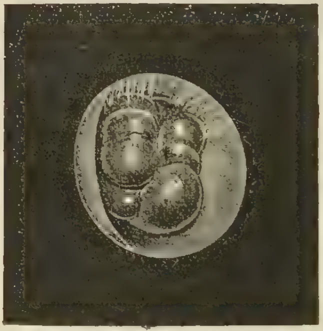


FIG. 422.

FIGS. 419-422.—APPEARANCE OF THE MEMBRANE IN VARIOUS CIRCUMSTANCES ON EXAMINATION THROUGH A SPECULUM.

By permission, from Mr. Albert A. Gray's 'Diseases of the Ear.' London: Baillière, Tindall and Cox.)

Fig. 419.—Normal membrane (right side).
Fig. 420.—Perforation below and in front of head of malleus (left ear) in acute otitis suppurativa.
Fig. 421.—Perforation through Shrapnell's membrane in chronic otorrhœa.
Fig. 422.—Polypi protruding through perforation in membrane.

The **Eustachian Catheter** (Fig. 418) can be passed into the Eustachian tube, and the degree of inflation more accurately controlled. The instrument, carefully sterilized, is passed with the beak downwards along the inferior meatus of the nose until the posterior pharyngeal wall is reached. 'As soon as its tip touches the posterior wall of the naso-pharynx, the *anterior end* of the instrument is slightly raised, and is withdrawn for about half to three-quarters of an inch until the beak is felt to be in contact with the posterior end of the hard palate. The catheter is then rotated through a quarter of a circle until the beak points directly outwards. It is then pushed a little onwards, and is usually felt to slip easily into the opening of the Eustachian tube' (Lambert Lack).

The **External Ear** is the site of various affections which may come under the observation of the general surgeon. Thus, the pinna may be **congenitally absent,** and even the external meatus closed, a malformation often associated with macrostoma. Nothing can be done for this want of development, and the surgeon must never be tempted to try and dig out the concealed membrana tympani. More frequently **accessory auricles** are present, consisting merely of fibro-cartilage covered with fat and skin. **Large and prominent ears** constitute a very unsightly deformity, for which operative interference is occasionally required. The size may be diminished by removing a V-shaped portion from the upper part; the prominence, by excising a portion of skin and cartilage through an incision on the posterior aspect. The wounds thus produced are accurately sutured together, and considerable improvement in the appearance results. **Hæmatoma** of the ear is usually due to injury, but is occasionally idiopathic in origin, especially amongst the insane. The auricle becomes swollen and enlarged, and of a bluish-red colour in traumatic cases (Fig. 423); unless the swelling is punctured and the blood let out, considerable deformity will result from its organization. **Eczema, boils,** and other inflammatory affections, as also sebaceous cysts, are met with in the external ear and pinna, but call for no special mention.

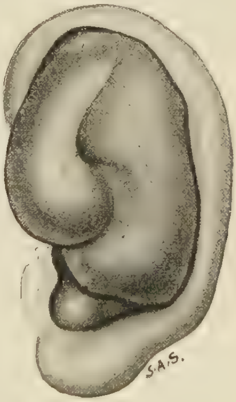


FIG. 423.—HÆMATOMA AURIS.

Plugs of wax (cerumen), which become dark and indurated, not unfrequently block the meatus, leading to more or less complete deafness; this may come on suddenly after bathing, owing to the plug rapidly swelling up. If they encroach on the membrana tympani, subjective symptoms of giddiness, vomiting, and rushing noises in the ear may also be caused. On examination with an ear speculum their presence is readily detected. *Treatment* consists in washing them away, after previously softening with oil or glycerine. A large syringe with a fine nozzle should be used, and a stream of warm water injected along the roof of the meatus; as it returns, the softened masses of wax are washed away. **Foreign bodies** in the meatus, such as buttons or beads, are similarly removed, if possible, by syringing; if this fails, a fine pair of forceps is employed for the purpose, but it must be remembered that behind the foreign body lie delicate structures, which can readily be harmed by the exhibition of impatience or force. Where all other plans fail, the auricle may be turned forwards and the meatus opened from behind. **Exostoses** are occasionally met with springing from the bony walls of the meatus; they give rise to deafness by obstructing the passage, and may be removed by the dental drill.

Affections of the Middle Ear.

Traumatic Rupture of the Tympanic Membrane is due to direct or indirect violence; the former includes the introduction of foreign bodies, or the ill-advised efforts of friends or even of medical practitioners to remove the same; the latter causes rupture of the membrane by the sudden compression of the air in the external meatus—*e.g.*, by boxing the ear, loud noises as from explosions or big-gun practice, or from diving. The lesion also occurs not uncommonly in fractures of the middle fossa of the skull. The patient complains of pain and deafness, and blood escapes from the meatus, but not to any great extent. On inflating the drum-chamber, as by Valsalva's or Politzer's methods, air can be heard to escape through the opening, perhaps with a whistling sound. As a general rule, these cases do well, the wound cicatrizing, and the hearing being fully restored; but the surgeon must at first give a guarded opinion, as there may be some deeper lesion which does not immediately become apparent. The greatest care must be taken to sterilize the meatus, although it is not wise to use a syringe for the purpose; the meatus is filled with 1 in 20 carbolic lotion, which is allowed to soak in; by this means infection of the tympanic cavity with pyogenic organisms may be prevented. A strip of gauze is then gently inserted into the meatus, and an external dressing applied.

Otitis Media.—Inflammation of the middle ear is an exceedingly common affection, and constitutes the great bulk of all ear diseases. It must be remembered that the tympanic cavity is lined by a mucous membrane which is in direct communication through the Eustachian tube with that of the naso-pharynx; and hence the *cause* is almost invariably an extension of inflammation along the Eustachian tube, and the organisms usually present are the pneumococcus or ordinary pyogenic cocci. The inflammation may be catarrhal or suppurative, acute or chronic. We can here only refer very briefly to that most commonly associated with surgical lesions.

Acute Inflammation of the Middle Ear is very common in children, being secondary to lesions of the naso-pharynx, such as an ordinary cold, adenoids, scarlatina, measles, etc. It is ushered in by severe pain in the ear (earache) of a boring, persistent character, together with deafness and perhaps some degree of fever. The pain increases as the secretion accumulates, and if the Eustachian tube becomes closed in consequence of the inflammatory hyperæmia of its lining wall, the tympanic membrane bulges outwards into the meatus and finally ruptures (Fig. 420), the pain being at once relieved. The discharge is mucous, or purulent from the first; in the former instance, if infection from the meatus is guarded against, the inflammation may subside, the perforation heal, and no ill result follow. In many instances, however, especially when the child is suffering from measles, or if his resisting powers to microbic invasion are low, pyogenic infection follows, and the catarrhal otitis media is transformed into a suppurative lesion, which may persist as a *chronic otorrhœa* for a lengthy period, and may lead to the most serious results.

It is therefore obvious that the greatest care should be taken in the **Treatment** of all cases of acute otitis media. In the first place, the possibility of infection from the external meatus must be guarded against by thoroughly purifying it; the external ear is well washed with soap and water, and the meatus is filled with 1 in 20 carbolic lotion, which is allowed to soak in and act for some minutes. An antiseptic dressing is then placed within and over it. The child is kept in a warm room, and his general condition attended to by suitable diet, diaphoretic medicine, and a smart purge. In mild cases a blister behind the ear will often act beneficially, whilst in more acute ones leeches may be applied. Solution of cocaine or drops of laudanum instilled into the meatus may relieve pain, and in adults it may be possible to cocainize the orifice of the Eustachian tube in the pharynx, thereby relieving the hyperæmia and opening up the tube, and thus giving an exit to the retained discharge. Pain is often relieved by fomenting the ear or by the application of dry heat, as in the form of a hot-water bottle or a baked bran-bag.

When the membrane is seen (by speculum) to be bulging, it is wise to incise it, as a clean cut often heals better than the ragged perforation made by Nature. Local or general anæsthesia is required, and the incision is usually made just behind and slightly above the handle of the malleus downwards and backwards. An antiseptic dressing is left in and over the meatus until healing has occurred.

Chronic Otorrhœa, as already explained, is a common sequence of an acute attack, which may have been purulent from the first, or may have been the result of a pyogenic infection from without of a simple catarrhal otitis media. The membrane is perforated, and the discharge varies in amount and character. In uncomplicated cases, treatment consists in: (1) Improvement of the general health, as by the administration of tonics, residence in fresh country air, and avoidance of chills. (2) The naso-pharyngeal condition must be attended to, so as to ensure a patulous condition of the Eustachian tube, by which discharges may escape. Gargles may be ordered, and adenoids and enlarged tonsils may require removal. (3) The middle ear must be kept free from any accumulation of discharge which might undergo decomposition. When the discharge is abundant, external syringing with sterilized salt solution or weak boric acid solution is needed, and the tympanic cavity is inflated from the Eustachian tube by Valsalva's method, Politzer's bag, or even the

Eustachian catheter, once or twice a day. If the discharge is offensive, or difficult to dislodge, peroxide of hydrogen (10 volume strength) will be found useful. If the discharge is slight, the meatus may be packed with boric acid powder, and syringing avoided. Not unfrequently, however, a persistent discharge from the ear is due to some of the complications mentioned below, and further operative treatment may be required.

The **Surgical Complications of Chronic Otorrhœa** are often serious, and call for prompt treatment; they may be classified under three headings—the extracranial, the cranial, and the intracranial.

The **extracranial complications of otorrhœa** are comparatively unimportant. (*a*) **Eczema** of the meatus is frequently seen, and merely needs the parts to be kept dry and clean, and possibly a little boric acid powder insufflated; it readily disappears when the discharge ceases, but is not unfrequently associated with enlargement of the cervical glands, which may suppurate or become tuberculous. (*b*) **Boils** arise from infection of the sebaceous glands in the meatus with pyogenic cocci from the discharge, and are exceedingly painful owing to the denseness of the tissues involved. They should be fomented, and opened when pus has formed. (*c*) Inflammation may occasionally spread from the meatus to the tympanic plate of the temporal bone, leading to subperiosteal abscess and necrosis; or it may extend into the temporo-maxillary articulation, giving rise to suppurative arthritis and disorganization of that joint (p. 811).

The **cranial complications of otitis media** are often of a grave nature, and may produce deafness, or even endanger life.

(*a*) The **ossicles** become ankylosed, or may die and be cast off in the discharge, the hearing being impaired in either case, but not necessarily destroyed.

(*b*) The inflammation may extend from the lining membrane of the tympanum to the bony walls surrounding it, giving rise to a limited **caries** or **necrosis of the temporal bone.** This may be associated with suppuration within the skull, and any of the intracranial complications mentioned below. The roof of the tympanic cavity (*tegmen tympani*), which is very thin, is especially liable to be affected in this way. If diseased bone can be felt through the external auditory meatus with a probe, an attempt should be made to remove it; if this is impossible, the part must be kept clean by the injection of mild antiseptics, retention of discharges being prevented by the regular use of Politzer's bag.

(*c*) **Polypi** may also develop, consisting essentially of granulation tissue protruding through the opening in the membrane (Fig. 422) thereby hindering the escape of the discharge. They should be removed by the snare or curette, and the base touched with a saturated solution of chromic acid; the part is subsequently syringed with a weak carbolic solution and dressed antiseptically.

(*d*) **Facial Paralysis** not uncommonly arises from sclerosis and thickening of the bony tissue surrounding the aqueductus Fallopii, causing pressure on the facial nerve in the canal. It must be remembered that the bony canal lies immediately behind the tympanic cavity, and to the inner side of the passage from the attic to the mastoid antrum (*aditus ad antrum*). For symptoms and treatment, see p. 384.

(*e*) **Involvement of the Internal Ear** or **Labyrinthitis** results from the spread of the infection inwards, either through the wall of the external semicircular canal, or through the fenestrum rotundum or ovale; in the former case the posterior or vestibular portion is involved, in the latter the cochlea. Invasion of the semicircular canals is usually evidenced by vertigo, a tendency to fall towards the affected side, nystagmus and vomiting; pain and fever are present in the more acute forms. Involvement of the cochlea is generally a later manifestation, and results in tinnitus and absolute deafness. Infection of the meninges sometimes arises by spread of inflammation along the internal auditory meatus.

(*f*) Inflammation may also extend into the mastoid cells, giving rise to the condition known as **mastoiditis.** The mastoid process is a triangular mass of bone, which is practically undeveloped until the age of puberty. Before that period a single cell relatively of large size communicates with the posterior portion of the tympanic cavity and represents the antrum; it is comparatively superficial, being immediately under cover of the squamous flake of bone, and is in reality petro-squamosal rather than mastoid in origin. After puberty the whole bone may become hollowed out into a series of spongy cells, lined with mucous membrane, which open into the floor of the antrum; or it may develop but few cells, and remain more or less solid. These cells lie below and superficial to the antrum, which is therefore more deeply placed in the adult than in the child. The communication with the tympanic cavity, which in a child is widely open, becomes encroached on in the adult, and narrowed to the small track known as the aditus ad antrum. When the inflammation in otitis media becomes purulent and extends into the antrum, severe local and general symptoms are likely to result. The patient complains of intense pain in the ear, with tenderness on pressure, and perhaps redness and œdema over the mastoid process. The discharge from the ear often ceases for a time at the commencement of these symptoms, but reappears later on. As the case progresses, febrile symptoms of an intermittent type, and even rigors, may supervene, whilst the patient becomes drowsy, or may be irritable and restless. An abscess may form under the periosteum covering the mastoid process, with or without caries or necrosis of the outer table of the bone; in children, where this bony lamella is thin, it is not unfrequently absorbed, and on incising the abscess protuberant masses of granulations, springing from the interior of the bone, may be seen. When such an abscess has developed, the auricle is characteristically displaced downwards and outwards. Not unfrequently the suppuration extends through the bone cells and may encroach on the inner aspect rather than the outer, and hence is likely to lay bare the dura mater and expose the lateral sinus; in such circumstances intracranial complications are probable (Fig. 369). Occasionally a few thin-walled cells occupy the tip of the mastoid;

and these, if involved, may perforate downwards, and thus an abscess may form under cover of the sterno-mastoid, and track into the neck; this is known as *Bezold's perforation* (Fig. 369, F). At times the trouble is of a more chronic type, and is then associated with the more solid form of mastoid process. Sometimes it is tuberculous in nature, the cells being choked up with lymph and inflammatory material of a cheesy nature, whilst the bone itself becomes thickened and condensed. The process feels distinctly enlarged, and is the seat of a good deal of deep-seated pain of an aching character, and worse at night.

When the discharge is inspissated and mixed with epithelial cells and cholesterine, so as to form flaky masses like the layers of an onion, the condition is known as *cholesteatoma*. It is often the cause of great distension of the antrum, which in one case operated on measured quite 1½ inches across. The symptoms, at first of a chronic type, are likely to be followed sooner or later by an acute attack of suppurative inflammation.

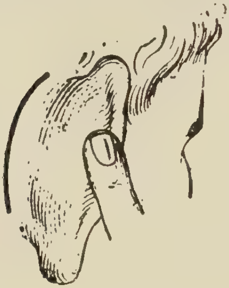


FIG. 424.—INCISION FOR MASTOID OPERATIONS.

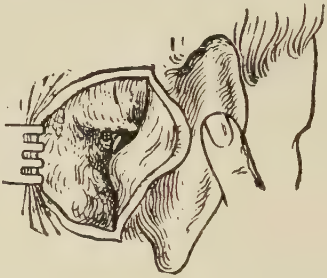


FIG. 425.—SITE FOR DRILLING BONE IN ORDER TO OPEN THE MASTOID ANTRUM.

It is often well to apply a chisel over the desired area so as to include a triangle, the centre of which corresponds to the apex of the so-called supra-meatal triangle. As soon as the outer layers of the bone have been removed by the chisel, the gouge is used to reach the deeper parts.

Treatment.—In the early acute stage belladonna fomentations may be employed, and the patient kept quietly in bed, whilst the diet is regulated and a suitable purgative administered; accumulated discharge is removed from the tympanum by the use of Politzer's bag. Two or three leeches may also be applied over the mastoid process, and relief to the pain thus obtained, though it is often only of a temporary character. It is most important not to rely upon such palliative measures for too long, but if the symptoms are well marked, the mastoid *antrum must be laid open* and its contents evacuated without interfering with the tympanic structures which in acute cases are capable of effective repair (*Schwartze's operation*). A curved incision is made immediately behind the ear, which is drawn well forwards (Fig. 424), and a gouge or burr worked by a surgical engine, applied on a level with the roof of the external auditory meatus, and about ½ inch behind its centre (Fig. 425). A small dimple in the bone can often be felt at the required spot, which can also be found by taking the point of junction of two lines drawn as tangents to the roof and posterior wall of the bony meatus respectively (Fig. 370, C). The direction taken by the gouge should be slightly downwards, forwards, and inwards, and a useful guide will be found in a probe passed down the external auditory meatus, the boring being made exactly parallel to this. In an adult the mastoid antrum is reached about three-fifths of an inch from the surface of the bone. The surgeon recognises that he has opened the cavity by the probe, or by the loss of resistance and escape of offensive pus. The opening is enlarged by the use of the gouge and spoons, so as to expose all the affected bone cells and remove all diseased bone, and the cavity is then syringed out. The wound is packed with sterile gauze and should be syringed daily. A Bezold's perforation must be enlarged, and possibly an incision in the neck may be prevented, if the case is treated early.

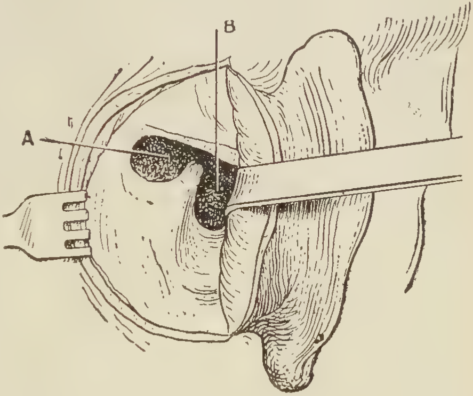


Fig. 426.—Stacke's Operation completed.

The antrum (A) has been thoroughly opened up, and the bridge of bone covering the aditus removed, thus bringing the antrum into free communication with the tympanic cavity (B), which is curetted and the ossicles removed.

In the more chronic cases, where tympanic complications are present, a more extensive proceeding known as *Stacke's operation* is usually required. In it the auricle is detached posteriorly from the bony margins of the meatus, and then the antrum is opened and the whole of the osseous tissue intervening between it and the meatus and tympanic cavity in front is gouged away. A metal guide is passed from the opening in the antrum into the attic along the aditus, and all the bone superficial to the guide may be safely removed. The facial nerve and superior semicircular canal lie behind, and are protected by the guide. The remains of the membrane and the ossicles are then removed, and the cavity curetted (Fig. 426). The deep portion of the posterior wall of the cartilaginous meatus is incised longitudinally and the margins of the aperture stitched to the posterior edge of the wound, the meatus thus leading to the whole of the opening in the bone, which can in this way be syringed out and cleansed more efficiently.

The **intracranial complications** of otorrhœa are subcranial abscess, localized or diffuse meningitis, thrombosis of the lateral sinus, and abscess in the cerebrum or cerebellum.

(*a*) **Subcranial Abscess.**—For general phenomena connected with this condition, see p. 764. Accumulations of pus occur most commonly along the summit of the petrous portion of the temporal bone (Fig. 369, B), and in the sulcus in which the lateral sinus is lodged. The patient complains of pain and headache, which increase for a time and are then followed by drowsiness, which may pass into coma. The temperature is raised, but rigors, even if present at first, are by no means a constant feature of the case. The pulse is of the usual febrile type, viz., quick, full, and bounding. There is no pain in the neck along the course of the jugular vein, but retraction of the head occurs if basal meningitis is present, and vomiting is a marked symptom. Optic neuritis may be observed in consequence of the inflammation extending to the membranes at the base of the brain. There may be some tenderness on pressure over the temporal region, and possibly œdema. In some cases the pus finds its way outwards along the mastoid emissary vein, or through the suture between the occipital and temporal bones.

The **Diagnosis** from *cerebral abscess* is sometimes a matter of considerable difficulty. The symptoms, however, set in somewhat more acutely, whilst the temperature is raised, and the signs of irritation of the membranes, such as retraction of the neck, all suggest that the lesion is extradural, and not cerebral in origin. The pulse is fast, and not slow, and focal symptoms are less likely to develop.

The **Treatment** consists in trephining above and behind the meatus, so as to escape the lateral sinus, and in much the same situation as for a temporo-sphenoidal abscess (*q.v.*). The pus is washed out, and a drainage-tube inserted for a few days.

(*b*) **Meningitis** may be localized or diffuse. The former often accompanies some other condition, and is in itself of little moment. It may produce fixed headache, but, if non-suppurative, usually disappears when the originating disease has been cured. The diffuse variety is generally infective in nature, and secondary to some suppurative affection in the neighbourhood, or to thrombosis of the lateral sinus. (For symptoms, see p. 766). Occasionally a simple serous effusion occurs within the meninges, leading to increased pressure and consequent drowsiness, but disappearing entirely when the cause has been removed, or the excess of fluid withdrawn by lumbar puncture.

(*c*) **Thrombosis of the Lateral Sinus** arises from direct extension of the inflammatory process from the middle ear through the mastoid bone (Fig. 369, E), or it may be set up by an infective thrombosis of the mastoid emissary vein spreading to the sinus. A clot forms within it, which, gradually increasing in size, leads finally to occlusion of its lumen. Infection with pyogenic organisms determines disintegration of the clot; infected emboli are detached, and thus pyæmic symptoms originated. In well-marked cases the thrombus extends as far back as the Torcular Herophili, and downwards along the jugular vein.

The most marked **Symptom** of the case is the sudden appearance of a high temperature, which is usually remittent, and associated with rigors, vomiting, and localized pain in the head, perhaps most marked over the point of emergence of the emissary vein at the posterior border of the mastoid process. The pulse is rapid, feeble, and easily compressible, and in the later stages the patient is drowsy and dull, probably from serous exudation within the meninges. The discharge from the ear, which may have been previously offensive, usually ceases. Optic neuritis may or may not exist, being often preceded by photophobia. If the thrombus extends into the neck, a firm, tender, elongated swelling is felt in the region of the jugular vein, and, owing to the interference with the venous circulation, the face often becomes dusky. The cervical lymphatic glands become enlarged, and stiffness of the muscles at the back of the neck is an evidence of associated basal meningitis, as is also the optic neuritis. Suppuration may occur outside the sinus, or around the vein in the neck, which becomes swollen, red, and œdematous.

In well-marked cases the **Diagnosis** is easily made, but in the early stages, and especially in children, it is often a matter of some difficulty. The abrupt onset, the oscillating temperature, the recurrent rigors, the pain in the neck, and the deep tenderness on pressure over the course of the lateral sinus or jugular vein, are the most trustworthy signs of this affection.

Treatment.—A radical mastoid operation is usually undertaken first, and by extending its scope backwards the sinus can be exposed. Apart from this, the sinus is laid bare by applying a trephine at a spot about $\frac{1}{4}$ inch above Reid's base-line, and about 1 inch behind the centre of the external auditory meatus (Fig. 370, A or B). A puncture with a fine needle readily determines whether the sinus contains fluid blood or thrombus. If it is thrombosed, there is often some evidence of inflammation or pus around it, between the dura mater and the bone. Having thus verified the diagnosis, an incision is made along the anterior border of the sterno-mastoid, through which the jugular vein is tied at a spot below the lowest point of the thrombus, so as to prevent the escape of any more emboli into the general circulation. In old-standing cases this may involve exposing the vein in the lowest part of the neck, and placing the ligature close to the innominate. The lateral sinus is now freely incised, and the infected thrombus partly scraped, partly washed away, the opening in the bone being increased in size, if necessary. It is desirable, but not essential in the simpler cases, to remove completely the lower part of the thrombus; if such is attempted, the jugular must be opened above the ligature, and the clot syringed or scraped away. Bleeding occurs from the posterior part of the upper opening as soon as all the coagulum is removed, but is easily controlled by plugging the sinus with a small piece of aseptic gauze. The wound in the neck should be lightly packed and not closed, since infection and suppuration are almost certain to follow. The upper wound is also packed in the same way, and allowed to granulate.

(*d*) **Abscess** in the cerebrum or cerebellum, a complication not unfrequently met with, has been already discussed (p. 769).

CHAPTER XXXII.

SURGERY OF THE NECK.

Affections connected with the Branchial Clefts.—In the second or third week of intra-uterine life a series of branchial arches form in the human embryo as in other mammalia, constituting the foundation from which the future structures of the neck are developed. In the majority of mammals five such post-oral arches occur, separated from one another by the so-called branchial clefts; but in man the fourth and fifth are amalgamated. They project from the side of the primitive spinal column, and consist of mesoblast lined on either side by epithelium. They unite across the median line at an early date, and also one with another, thereby leading to a large extent to the obliteration of the clefts. Occasionally, however, this union is imperfect, and sundry malformations result.

It must be remembered that the mandible and the processus gracilis of the malleus arise from the first arch; the Eustachian tube, tympanic cavity, external auditory meatus, and Glaserian fissure from a normally unobliterated portion of the first cleft; the styloid process, stylo-hyoid ligament, and lesser cornu of the hyoid bone from the second arch; the body and great cornu of the hyoid bone from the third arch; and the rest of the cervical tissues from the remaining arch; whilst the second, third, and fourth clefts are, under ordinary circumstances, totally obliterated.

Branchial Fistulæ are due to imperfect closure of the branchial clefts. They consist of narrow sinuous tracks extending inwards from the skin, and perhaps communicating, but not necessarily so, with the pharynx. The external opening is usually situated along the anterior border of the sterno-mastoid, and most commonly near its lower end, close to the episternal notch, the fistula then arising from the lowest cleft. They are lined with epithelium, and secrete a glairy or mucoid fluid. They are not uncommonly associated with other abnormalities, such as macrostoma, absence of the pinna, or accessory auricles situated either near the orifice of the fistula or close to the ear. In the majority of cases they may be disregarded, but if troublesome should be laid open and the lining membrane either dissected away or destroyed with the galvano-cautery.

Branchial Cysts arise from incomplete closure of a branchial cleft, the unobliterated portion becoming distended with secretion. They usually appear in adolescents, often between the ages of ten and twenty, and are frequently attributed to a blow, which, it may be presumed, brings into activity structures which would otherwise have remained passive. They grow slowly and painlessly, forming rounded swellings, often rather soft, with more or less distinct fluctuation, according to the depth at which they are situated; their contents, if near the cutaneous end of the cleft, are sebaceous in character, similar to, but more fluid than, that found in dermoid cysts (viz., flattened epithelial cells, cholesterine plates, and fatty granules). If placed nearer to the pharynx they are occupied by a glairy mucoid fluid. They are usually lined with squamous epithelium, but a few cases have been recorded in which the cells were columnar, and even ciliated, in character. The most common situation is in the third cleft, the cyst then lying between the thyroid cartilage and the anterior border of the sterno-mastoid, in relation with the great wing of the hyoid bone; when of large size, they may extend beneath that muscle, displacing it outwards. More rarely a cyst arises from the second cleft, being then located in the upper third of the neck, and spreading up towards the styloid process; it may even reach from the mastoid process to the hyoid bone, running parallel to the posterior border of the jaw, and fluctuation may be detected through the mouth. *Treatment* consists in extirpation when the condition has attained sufficient size to be troublesome.

Branchial Carcinoma.—Considerable doubt has been expressed as to whether it is possible for carcinoma to originate in the unobliterated remains of the branchial clefts, cases which might have been considered of this nature being ascribed to developments of epithelioma in the deep lymphatic glands which have undergone cystic degeneration, and secondary to some undiscovered or aborted lesion in the pharynx or larynx. The balance of evidence is, however, in favour of the fact that carcinoma can start in this way, giving rise to what has been described as a *malignant cyst of the neck.* It is characterized by the formation of a tumour placed deeply beneath the sterno-mastoid, indefinite in outline, and of firm consistence. Considerable pain is experienced, and lymphatic glands become secondarily enlarged. The disease runs its ordinary course, but may destroy life through hæmorrhage from the main vessels, which are invaded by the tumour. The cyst sometimes gives way into the pharynx, and a malignant ulcer of the pharyngeal wall is thus induced. Pathologically, the condition is an epithelioma. *Treatment* is usually impracticable owing to the deep connections of the growth.

Various other congenital conditions may be met with in the neck. **Congenital induration of the sterno-mastoid** in all probability arises from injury during parturition, and usually occurs in head presentations, probably from bruising of the side of the neck against the under surface of the symphysis; it is said to be more common on the left side than on the right. In cases that have been examined microscopically, the indurated mass has been found to consist of fibrous tissue. It disappears spontaneously after a time, but may lead to torticollis at a later date. The congenital form of **torticollis** (p. 432), **cysts** in connection with the thyro-glossal duct, and **cystic hygroma**, may also be mentioned.

Cysts of the Neck.

I. **Cysts of Congenital Origin.**—(*a*) *Dermoids* occur here as in any other region where congenital remains are found. As already mentioned, they may develop laterally from the branchial clefts, but may also be found in the middle line, or in connection with the thyro-glossal duct. (*b*) The *thyro-glossal duct* (Fig. 427) consists of a tubular outgrowth from the embryonic pharynx passing downwards behind the body of the hyoid bone in front of the larynx and trachea as far as the isthmus of the thyroid gland, which is subsequently developed from it, and unites with the lateral lobes, which in turn spring from the deeper parts of the branchial arches. The upper end of this duct is situated at the foramen cæcum of the tongue, and thence traverses the substance of that organ between the genio-hyo-glossi muscles to reach the hyoid bone; the lower end is represented by the pyramid of the thyroid isthmus. The whole of this tube disappears under ordinary circumstances; if, however, the upper part remains unobliterated, a dermoid cyst may originate from it, placed either in the substance of the tongue or immediately below it (p. 838). If the lower portion remains patent, a cyst develops containing mucoid or glairy fluid, which, however, is not present at birth. If it bursts spontaneously, or is opened, a so-called *median cervical fistula* results, which requires the same treatment as a branchial fistula, viz., incision, and complete removal or destruction of the epithelial lining. Accessory thyroid growths of an adenomatous nature may develop from any part of the duct, but especially from the lower end; they are quite innocent in nature, and unless

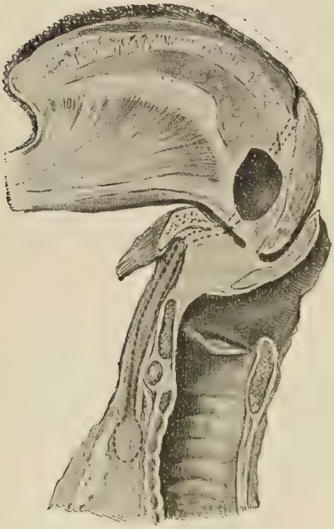


FIG. 427.—MEDIAN SECTION OF TONGUE, LARYNX, AND TRACHEA, SHOWING THYRO-GLOSSAL DUCT EXTENDING FROM THE FORAMEN CÆCUM OF THE TONGUE DOWNWARDS BEHIND THE HYOID BONE, AND IN FRONT OF THE TRACHEA TO THE ISTHMUS OF THE THYROID BODY (SEMI-DIAGRAMMATIC, FROM COLLEGE OF SURGEONS' MUSEUM.)

A small dermoid cyst in the centre of the tongue is also represented.

troublesome may be left alone. (*c*) *Cystic hygroma* is sometimes congenital, but may also be acquired. It consists of a multilocular swelling, the spaces composing it being due to dilatation of lymphatic spaces, and filled with lymph. The tumour is often of considerable size, with a sinuous, irregular outline, and may produce great deformity and marked pressure effects. The skin over it may be occupied by dilated capillaries or lymphatics. Unless extending to inaccessible parts, such as the superior mediastinum, it should be dealt with by excision (p. 359).

2. **Acquired Cysts of the Neck** are of the following types: (*a*) *Sebaceous cysts* develop in the skin as elsewhere, but need no separate notice. (*b*) *Bursal cysts* are stated to occur in connection with the larynx and hyoid bone. There is usually a bursa over a prominent pomum Adami, and this may become enlarged and distended with fluid. A bursa is also stated to exist between the back of the hyoid bone and the thyroid cartilage, which might easily be mistaken for one of thyro-glossal origin. In doubtful cases a microscopical examination of the lining wall will quickly settle the diagnosis, since if it is bursal in origin it is lined with endothelium, whilst if it is thyro-glossal it is lined with epithelium. In the former case incision and drainage usually suffice to bring about a cure, although excision is preferable; in the latter case the lining wall must be entirely removed. (*c*) *Unilocular serous cysts* are sometimes met with in the lower part of the posterior triangle, constituting the condition known as ‘ hydrocele of the neck.’ They contain serous fluid, with perhaps an admixture of blood. Their origin has not been defined with any certainty, but they are probably due to a dilatation of the lymph spaces, and are best treated by excision. (*d*) *True hydatid cysts* also occur in this region (p. 233). (*e*) *Blood cysts* have been found in close connection with the large vessels of the neck. They are possibly due to the dilatation of a vein, and may communicate or not with some vascular channel, such as the jugular, being then partly emptied on pressure. Where no communication with a venous trunk exists, the lining membrane is intensely vascular. If their vascular origin is recognised, they should be left alone unless causing urgent symptoms. If, however, a blood cyst is opened by mistake, the supplying vessels must be secured, if possible, and, failing that, the cavity must be packed with gauze soaked in adrenalin. (*f*) Cysts are also occasionally met with in connection with the *salivary* glands and the *thyroid* body. (*g*) *Malignant cysts* arise, as already mentioned, from the remains of the branchial clefts, or from a degeneration of epitheliomatous lymphatic glands. They are often of large size, and their removal is impracticable owing to the adhesions which they contract to the deeper structures.

Cut Throat.

Injuries of the neck are commonly met with in cases of attempted homicide or suicide, and vary much in severity according to the extent and position of the wound. A right-handed suicide usually cuts his throat from left to right, and therefore the incision is bold and clean on the left side, tailing off towards the right; in a left-handed suicide the incision runs in the opposite direction. A homicidal cut throat varies in its direction according to whether it is done from behind or in front, and also with the hand employed. If the front of the neck is mainly involved, the air-passages are laid open, and the patient's life, though much endangered, is not necessarily destroyed. If, however, the wound chiefly affects the side, the great vessels and nerves may be divided, and death from hæmorrhage is very liable to ensue. The course and treatment of the latter class of case require no particular notice, since the general principles relating to all wounds must be adhered to. Where, however, the air-passages have been opened, special complications arise, requiring suitably modified treatment.

Wounds involving the Air-passages, the result of cut throat, may be situated at four different levels: (*a*) above the hyoid bone, encroaching on the base of the tongue; (*b*) through the thyro-hyoid space, the most common situation; (*c*) in the larynx; and (*d*) opening or dividing the trachea.

The **immediate effects** of such lesions are due to shock, hæmorrhage, asphyxia, or the entrance of air into veins. *When above the hyoid bone,* the root of the tongue and submaxillary region are involved, and hæmorrhage from the lingual or facial arteries or their branches follows; if the wound extends far enough, the main vessels are divided, and death results. In the less severe cases the patient runs considerable risk of being suffocated by the epiglottis and base of the tongue falling back over the larynx. Much difficulty will be subsequently experienced in feeding the patient, owing to impairment of the movements of the tongue. When the *thyro-hyoid* space is opened, the facial and lingual arteries are again in danger, as also the upper part of the superior thyroid. The base of the epiglottis is divided, and portions of mucous membrane around the entrance of the larynx may be detached, and cause obstruction to respiration. Blood may also trickle down the larynx into the trachea, and lead to asphyxia. Wounds of the *larynx* are usually transverse, and not very extensive, owing to the resistance offered to the knife by the cartilage. The thyroid body may be wounded and bleed freely, otherwise there is but little hæmorrhage. Blood may find its way into the trachea or lungs, and asphyxiate the patient. When the *trachea* is involved, the common carotid and inferior thyroid vessels are very liable to be wounded, giving rise to severe, if not fatal, hæmorrhage. Asphyxia may be brought about by displacement of the severed portions of the tube, or from the entrance of blood into the air-passages, whilst air may also be sucked into opened veins. The recurrent laryngeal nerve may be divided, causing paralysis of the larynx.

The **secondary effects** following cut throat are mainly inflammatory in origin. (*a*) The wound is likely to become *infected*, giving rise to a cellulitis which may spread down to the mediastinum, or to œdema of the glottis. Secondary hæmorrhage also arises from this cause, and even general pyæmia. (*b*) *Inflammation of the air-passages*, tracheitis, bronchitis, or broncho-pneumonia, frequently follows, partly as a result of the entrance of cold air, partly from the admission of septic material, such as food, decomposing blood-clot, or discharges. The patient may become cyanosed from these causes, and in consequence of the partial asphyxia the sensibility of the mucous membrane of the glottis is diminished, allowing of the passage into it of food which appears at the mouth of the wound; in some cases this may have arisen from division of the superior laryngeal nerve, but the depth at which this structure is situated in the neck makes it difficult to conceive how it could be divided without injury to the main vessels. (*c*) *Surgical emphysema*, or the entrance of the atmospheric air into the cellular tissue, may also follow a wound of the air-passages. It is not limited to the neck, but extends to the trunk, being recognised by the puffy distension of the part, and by a soft crackling crepitus elicited on pressure. It is of no great consequence, and usually disappears in a few days.

The **Treatment** consists in securing all bleeding-points, if possible, but occasionally they are placed so deeply that it is necessary to tie the external carotid; general oozing from the surface must be attended to, for fear of blood being sucked into the air-passages. Every effort should be made to render the wound aseptic, and if there is a reasonable prospect that this has been attained, it may be closed by sutures in the ordinary way. Where, however, asepsis is doubtful, only the ends of the incision should be drawn together, the central portion being left open.

The treatment of the air-passages varies with the site of the lesion. If the trachea has been roughly divided, the portions should be steadied by a stitch on either side, and a tracheotomy-tube inserted —at any rate, for a few days; when cleanly cut, total closure without the use of a tube can be safely permitted. When the wound involves the larynx, it is desirable to close the opening at once, since the larynx does not readily tolerate the presence of a tube; if necessary, it is better to perform a high tracheotomy. When the wound involves the thyro-hyoid space, or is situated above the hyoid bone, it is quite safe in many cases to close the wound layer by layer after carefully disinfecting it. The mucous membrane is first dealt with by stitches which do not penetrate its whole thickness, and then a more thorough purification can be undertaken; if the epiglottis is divided, it must be accurately sutured. If there is any doubt as to the advisability of this proceeding, a high tracheotomy is first performed, and then the wound closed as far as possible.

In every instance the head should be flexed on the chest, and in suicidal cases a careful watch maintained to prevent the patient tearing the wound open. Loss of blood is dealt with by the infusion of saline solution, and the patient's general condition attended to. Feeding should always be undertaken through a tube passed into the œsophagus, whether that structure is wounded or not, and this should be continued until the patient's natural powers of swallowing are restored.

The following **Sequelæ** occasionally result from a cut throat: (*a*) An *aërial fistula* is a persistent abnormal communication between the air-passages and the external air, and occurs most often in the thyro-hyoid space, the skin and mucous membrane becoming continuous one with the other around the margins of the opening. In some cases it may be closed; but if laryngeal stenosis or adhesions are present, it must be left alone for a time until these conditions have been treated. The operation consists in separating the skin from the mucous membrane, and in order to accomplish this, the external wound must be enlarged vertically. The edges of the mucous membrane are then pared, and stitched together horizontally. The external wound is either closed vertically, or left partially open and packed. (*b*) *Laryngeal or tracheal stenosis*, due to the cicatrization of wounds in these regions, may be remedied by wearing an O'Dwyer's tube (p. 916) for a time, or may necessitate the constant use of a tracheotomy-tube. (*c*) *Aphonia* may arise from division of the recurrent laryngeal nerve, and is then usually persistent. (*d*) *Œsophageal or pharyngeal fistulæ* may also in rare instances complicate the healing of an extensive wound in the throat, but tend to close of themselves, and require no special treatment.

Diseases of the Thyroid Body.

Goitre.—Enlargement of the thyroid body, or, as it is termed, bronchocele or goitre, is a condition frequently seen in this country, and is of general, and not merely local, importance, since the thyroid body exercises considerable influence over metabolism and nutrition. Total absence or removal of the gland or its complete degeneration leads to accumulation of mucin in the body, producing myxœdema in adults, and cretinism in children; whilst the excessive absorption of normal or vitiated thyroid secretion is probably responsible for Graves' disease, and possibly to some forms of skeletal trouble.

The **Causes** of bronchocele are still enshrouded in a good deal of uncertainty. It occurs endemically in this and many other countries, being especially frequent in mountainous districts. At home the favourite sites are the hilly parts of Derbyshire and Gloucestershire (where it is known, in fact, as Derbyshire neck); it is exceedingly common in Switzerland and the valleys of Northern Italy, but also occurs frequently in relation with the Himalayas, Pyrenees, Andes, etc. Epidemics have also been known to occur, but rarely except in goitrous regions. There can be little doubt that the disease is due to the presence in the drinking-water of some living contagion, which probably develops in the intestinal canal and produces a peculiar toxæmia. Major McCarrison in his Milroy Lectures* has elaborated this thesis in a most convincing manner, and related at length his observations and experiments in connection therewith. Working with the goitrogenous waters of certain springs, he was able to produce the affection in animals (rats and goats) and in healthy men; if filtered effectively, the water had no result; the scrapings of the filter, however, if administered, produced goitre. These results coincide with the experimental findings of other workers in this field in Switzerland and elsewhere. Thus Wilms and Sazuli (Heidelberg) found that rats fed on cooked rice mixed with rat fæces, or injected subcutaneously with rat fæces, developed moderate goitres, whereas all other types of abnormal and vitiated feeding had no result. Mixing the contaminated food with KI or thyroidin gave a negative result. The goitre itself is probably always sterile and free from micro-organisms; the intestinal habitat of the germs is rather presumed than proven from the results of the employment of intestinal antiseptics and of vaccines of intestinal bacteria, but there can be little doubt as to the value of these suggestions.

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* *Lancet*, 1913, January 18 *et seq*.

Other contributory causes may assist in this development—*e.g.*, want of sunshine and air, as in the case of those who live in valleys into which the air does not readily penetrate, or in the underground kitchens and cellars of large towns, defective sanitary conditions, and the habit of carrying weights upon the head. The ordinary type of goitre seen in this country is much more common in women than in men; it is not hereditary to any great extent, and is not influenced by intermarriage; but it may be congenital, and then is associated with skeletal changes, defective growth, and intellectual weakness, constituting the condition known as cretinism.

Varieties and Clinical Features.—Four chief forms of goitre are described, viz.: The parenchymatous or simple, the cystic, the fibro-adenomatous, and the exophthalmic; but the thyroid body may become enlarged in other ways, giving rise to the conditions known as malignant goitre and acute goitre, whilst acute inflammation is sometimes seen.

General Features.—In all these cases the thyroid body is the site of a swelling involving its whole substance, or one or other of its lobes, or possibly the isthmus alone. Its consistence varies with the nature of the growth, but it always moves with the larynx on deglutition. In every form there is probably a certain amount of anæmia, whilst some of the symptoms characteristic of the exophthalmic variety are often produced even in simple cases, possibly from the excessive absorption of thyroid secretion. Pressure on surrounding structures leads to dyspnœa or dysphagia, and cerebral symptoms may arise from interference with the main vessels, which are displaced outwards. The trachea is especially liable to changes of situation and shape from its compression; it is usually flattened from side to side (*scabbard trachea*), and is sometimes pushed an inch or more from the middle line. Atrophy of the cartilaginous rings may also be induced, and if this results from the pressure of a cyst or adenoma of the isthmus, severe dyspnœa may be caused thereby. If, as sometimes happens, the goitre develops downwards, pushing behind the sternum (*retro-sternal goitre*), the trachea is likely to be compressed from before backwards, and respiration may then be accompanied by stridor, but with no aphonia. Pressure on the recurrent laryngeal nerve leads to harshness or loss of voice, and to spasmodic attacks of dyspnœa, which may even prove fatal. It must be clearly understood, however, that the effects produced by a goitre are not necessarily proportionate to its size; some of the smaller growths at times produce severe symptoms.

Simple or Parenchymatous Goitre (Fig. 428) consists of a diffuse overgrowth of the whole thyroid body, the parts retaining to a great extent their usual proportions. The enlargement is due partly to an overgrowth of the glandular tissue, but also to an accumulation of colloid material within the vesicles; a normal amount of fibrous stroma is usually present. The whole gland is generally involved, but possibly one lobe is larger than the other. It is soft and elastic to the touch, quite painless, and there may be some amount of lobulation. Not uncommonly it is associated with a cystic development or new formation of an adenomatous type. When the interstitial tissue is abnormally abundant, as often occurs in the later stages, the tumour feels harder than usual, and is more definitely lobulated. It is then termed a *fibrous goitre,* and if the sclerosis is very marked, myxœdema may supervene.

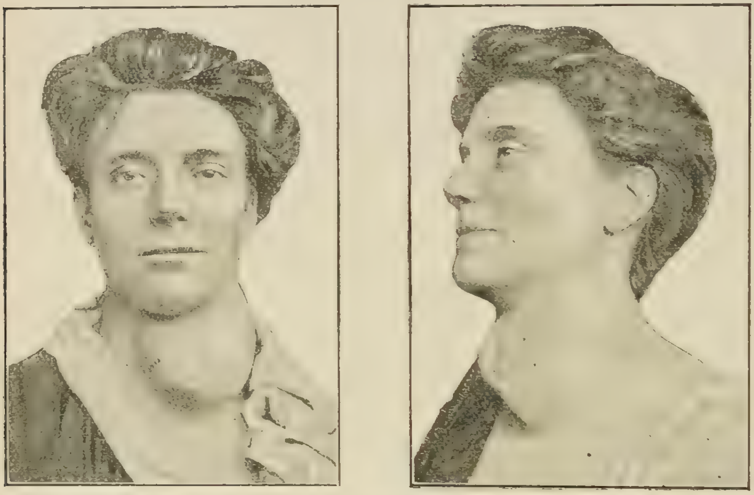

Fig. 428.—Front and Lateral View of a Parenchymatous Goitre

The right lobe had been removed by a former operation.

The **Fibro-adenomatous Goitre** (Figs. 429 and 430) consists in the development of one or more encapsuled adenomatous nodules in the substance of the thyroid body, which is itself often concurrently enlarged. These nodules may occupy one or other lobe, or, when multiple, be scattered through the substance of the organ; occasionally they develop in the isthmus alone. If situated near the surface their limitation and free mobility in the gland can be easily detected; but when placed deeply, their special features cannot be recognised. Two varieties have been described: (*a*) The fœtal, in which the growth is solid and homogeneous, consisting of closely apposed alveoli in which there is no colloid development, and identical in structure with embryonic thyroid tissue. Such growths are usually seen in young people; they are seldom very large, but frequently rather vascular. (*b*) The more ordinary type of adenoma resembles ordinary adult thyroid tissue more closely, and shows a considerable tendency to cyst formation. It is impossible to draw an exact line of separation between this latter condition and the simple hypertrophy, which is often of a diffuse adenomatous nature.

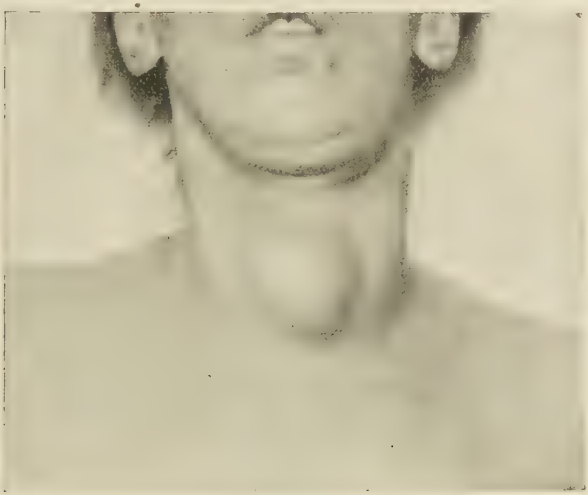

FIG 429.—FŒTAL ADENOMA OF RIGHT LOBE OF THYROID BODY IN A WOMAN AGED TWENTY-FIVE YEARS.

(From photograph kindly lent by Mr. James Berry.)

Cystic Goitre (**Cysto-adenoma**) arises from the dilatation into cysts of alveolar spaces in the normal gland tissue or in a localized adenoma, the interalveolar walls being absorbed. They may be single or multiple, and contain either a thin fluid or a thick grumous colloid material, somewhat like furniture polish. Intracystic growths of a papillary nature are not unfrequent. The lining membrane of these cysts is epithelial in nature, the individual cells being cuboidal when the cyst is small, and flattened out or even squamous when large. It is sometimes intensely vascular, and hæmorrhage into the cyst is by no means uncommon, causing the contents to be brown or blood-stained.

Secondary changes occur in any of these varieties, chiefly affecting the interstitial tissue, which may develop into cartilage or bone, or may calcify, but only in very chronic cases. Hæmorrhage into the alveolar spaces or cysts is not uncommon; acute infective inflammation may also involve the mass, and malignant disease, usually of a cancerous nature, sometimes supervenes.

As a rare complication may be mentioned general dissemination,* giving rise to secondary growths, which are usually found in the short and flat bones, especially the cranium and vertebræ, but occasionally in the viscera. Their texture is usually identical with normal thyroid tissue, but may be more cellular and of a cancerous type, and may be sufficiently vascular to pulsate. They produce local symptoms of varying gravity. The thyroid may be apparently normal or the site of a simple goitre.

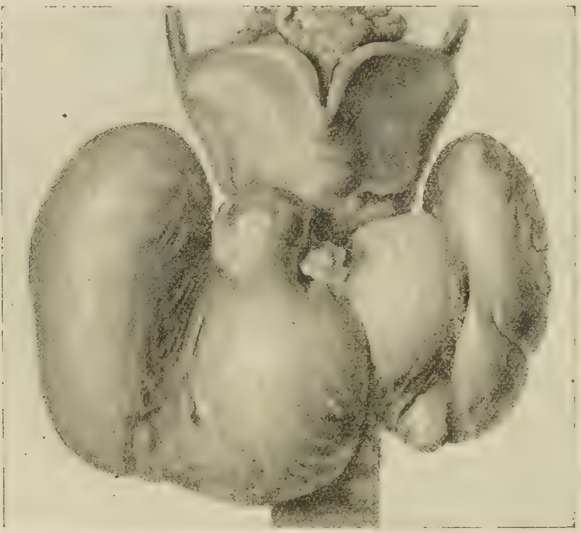

Fig. 430.—Multiple Fibro-adenomatous Goitre. (King's College Hospital Museum.)

The **Treatment** of the three preceding forms of goitre may be considered together, as they are very different in nature to those which follow. In the early stages palliative measures can be employed, consisting in the use of soft or distilled water, the improvement of the general health, and the correction of errors in the personal and sanitary hygiene. Change of air to the seaside is often advisable, whilst iron and iodides may be administered internally, and iodine paint applied locally, or driven in by cataphoresis (p. 54). In India cures are often produced by inunction of iodide of mercury ointment, the part being subsequently exposed to the rays of the midday sun; such treatment is generally impracticable in this country. The exhibition of thyroid extract or of the active principle of the gland isolated by Baumann and called 'thyro-iodine' is sometimes followed by a diminution of a simple goitre.

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* Patel, 'Tumeurs benignes du corps thyroïde donnant des metastases,' *Rev. de Chirurgie*, 1904.

In cases where, in spite of such treatment, the growth persists or increases in size, operative treatment should be undertaken in order to remove the tumour or a part of the gland. Total extirpation, as already mentioned, results in myxœdema; but as long as a sufficient portion of the secreting substance is left, whether it is derived from the isthmus or from one of the lobes, no such sequela need be feared. In fact goitres should be treated much in the same way as other new growths, viz., by removal when small; there is still, unfortunately, a considerable tendency amongst practitioners and patients to leave them untouched until they are of large size, thus greatly increasing the risk of the operation.

Partial thyroidectomy is conducted as follows: An incision is made over the most prominent part of the tumour, either along the lower third of the anterior border of the sterno-mastoid, or transversely across the neck in order that the scar may be less visible. The platysma and deep fascia are divided, and the sterno-mastoid, sterno-hyoid, sterno-thyroid, and omo-hyoid drawn aside, or, if need be, divided. The lobe to be removed is thus exposed within its capsule, which should not be opened. The limits of the mass are defined by the finger or a blunt dissector, and the vessels entering or leaving it are secured. The superior thyroid vessels are doubly ligatured and divided at the upper end of the growth, the middle thyroid vein is secured at the middle of its outer border, whilst the inferior thyroid vessels are dealt with below, special care being taken to avoid the inferior or recurrent laryngeal nerve by tying the vessels as near to the gland as possible. The lobe is now freed from the underlying structures, as also, if need be, the isthmus from the trachea. In detaching the latter, the surgeon must not forget that the cartilaginous rings may have been absorbed, and that the walls of the trachea, being then merely fibrous in nature, are easily wounded. The isthmus is divided, and any bleeding vessels secured; or if necessary, it may be ligatured before division. The wound is closed by buried sutures for muscles and fasciæ, and a Halstead's intradermic stitch for the skin. A drainage-tube may be required for twenty-four hours, as it is difficult to employ much pressure on the neck. Healing by first intention should be the invariable result, and the scar almost invisible.

The question as to the desirability or not of employing a general anæsthetic in these operations has been much discussed. Some surgeons, and notably Kocher, advise that local anæsthesia (Schleich's infiltration method) should be always employed; many others reserve that procedure for the worst cases, and trust to a skilled anæsthetist to administer safely a general anæsthetic to the majority of the patients. With this latter view we personally concur. When the growth is retro-sternal or the trachea much compressed, the intra-tracheal administration of ether is desirable.

Fibro-adenomata, or Cysts, when multiple or deeply placed, are treated by extirpation of the affected lobe; but if the new growth is single and superficial, it may be safely enucleated by dividing the skin and muscles as before, incising the gland substance and capsule down to the growth, which is readily shelled out.

Exophthalmic Goitre, or, as it is often termed, Graves' or Basedow's disease (Fig. 431), is a condition characterized by a diffuse enlargement of the thyroid body, which often pulsates forcibly owing to the dilatation of the vessels (particularly those in the capsule), associated with marked anæmia, severe palpitation and cardiac irritability (tachycardia), and protrusion of the eyeball (exophthalmos or proptosis). The disease is probably due to some derangement of the sympathetic or central nervous system, associated with definite changes in the thyroid body which result in the excessive absorption of thyroid secretion, either normal or vitiated in character. The enlargement of the thyroid body is not always marked, and indeed may be scarcely noticeable, but microscopic changes will always be found. The gland is more solid in texture than usual; the alveoli are small and crowded together, and often contain no colloid; papillary proliferation of the columnar epithelium lining the walls is present. The gland is always extremely vascular.

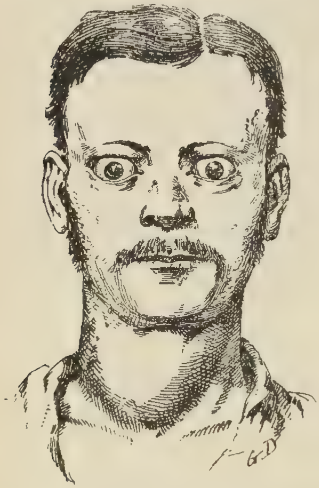

FIG. 431.—EXOPHTHALMIC GOITRE. (FROM A PHOTOGRAPH.)

The patients usually affected are females, about the middle period of life, whose menstrual functions are often impaired. Overwork, worry, and severe mental strain, are apparently responsible for the onset of the symptoms in many instances, and a sudden shock or fright accounts for others. The protrusion of the eyeball is a marked feature of most cases, and is sometimes due to an increase of the orbital fat. Contraction of the so-called muscle of Müller (unstriped muscular fibres stretched across the spheno-maxillary fissure) has also been suggested as a more plausible theory. When the patient looks down, the upper eyelid does not immediately follow the eyeball, allowing the white sclerotic to be seen between the lid and the cornea (von Graefe's sign). A fine fibrillary tremor of the limbs is also commonly observed in these cases. The patient is always extremely nervous, and the pulse-rate high; any exertion or excitement increases the irritability of the heart's action, and may induce considerable respiratory distress. The blood shows an increase in the lymphocytes, although the leucocytes generally are diminished in number. Left to itself, the disease in some cases tends to improve, but in others it may progress to a fatal issue from asthenia or cardiac complications.

Treatment consists in freeing the patient, if possible, from all sources of irritation and worry by absolute rest in bed, whilst bromides, iron, and perhaps iodide of potassium, are administered internally, attention being also directed to correcting menstrual derangements, or any other abnormalities of function or structure; thus, the cure of a nasal catarrh by cauterizing the nasal mucosa has several times led to a rapid amelioration of the symptoms. Phosphate of soda has been found useful in some cases, and Kocher speaks favourably of it when conjoined with suitable hygienic measures. Thymus and suprarenal extracts have sometimes proved beneficial, as also the blood-serum or dried blood of animals after thyroidectomy (antithyroidin).

Surgical treatment by removal of a portion of the gland is often followed by excellent results, although the proceeding is not devoid of serious risk, and should not be lightly undertaken. Half of the gland has usually been removed, but some surgeons have been satisfied with tying three of the thyroid arteries in order to starve the growth. General anæsthesia is decidedly dangerous in these cases, and it is better to rely on local anæsthesia, either of the Schleich type, or by cocainization of the superficial cervical nerve, which can be exposed at the posterior border of the sterno-mastoid at the level of the thyroid cartilage; 2 or 3 drops of a 2 per cent. solution should be introduced within its sheath. Patients are also very liable to syncope after the operation, and occasionally to a curious train of symptoms probably due to excessive absorption of thyroid secretion. The temperature a few hours after operation rises suddenly to 104° or 105°, the pulse-rate is greatly accelerated, and the patient becomes delirious and finally comatose, dying in that state in about forty-eight hours. The wound should be at once opened up, and probably a considerable quantity of a thin glairy fluid will be found within it; this should be soaked up by repeatedly packing the wound with dry sterile wool, or a drainage-tube may be inserted. In the cases that recover, a gradual improvement usually shows itself, but the full benefit of the operation is rarely gained under six or twelve months, and even then the exophthalmos often persists.

Malignant Disease of the Thyroid Body is more frequently cancerous in nature than sarcomatous, usually taking the form of an adenoid cancer, and almost always preceded by some variety of simple goitre. The tumour grows rapidly, infiltrating the surrounding parts, and causing enlargement of the lymphatic glands, and secondary deposits in the viscera and elsewhere. The trachea is severely compressed, and in some cases perforated; the main vessels are frequently surrounded by the growth, and not merely displaced as in the simple variety. Myxœdema may ensue as a late complication, owing to the total destruction of the glandular substance.

Treatment by extirpation can only be undertaken in the early stages.

Acute Goitre is but rarely met with, consisting of a rapid enlargement of the thyroid body, which attains a considerable size in the course of a few days or weeks. It affects young subjects, and is generally fatal from asphyxia due to pressure on the trachea or spasm of the glottis. Removal of one lobe under local anæsthesia is the only treatment that holds out any prospect of cure.

Inflammation of the Thyroid Body, or acute thyroiditis, occasionally supervenes as a complication of an ordinary goitre. It is almost always infective in nature, the cocci reaching it from without, as from tapping cysts or from a punctured wound, or from within the body in a pyæmic embolus, suppuration being usually induced; it sometimes occurs as a sequela of the acute specific fevers, or may follow a blow. The gland becomes enlarged, hot, and tender; fever and rigors follow, and the presence of pus is indicated by superficial œdema and fluctuation. The early **treatment** consists in the application of fomentations and perhaps leeches, or in the use of an ice compress. The patient is kept in bed, purged, and carefully dieted. Under such a régime, resolution may occur; but if, as happens more frequently, pus forms, free incisions should be made.

Accessory Thyroids sometimes develop above or below the isthmus, or are closely attached to one of the lateral lobes. They may be connected with the thyroid body, moving up and down with it on deglutition; or they may be independent of it, occurring in any part of the thyro-glossal duct, and even in the base of the tongue, in that situation resembling a dermoid cyst. If troublesome, they should be removed and subjected to microscopic examination, as their structure varies, and there is a possibility of recurrence.

Myxœdema (or cachexia strumipriva) is a curious condition, which, as already mentioned, supervenes when the thyroid body is totally removed, or so absolutely disorganized or infiltrated by a new growth as to be functionless. Although it is possible that we have still much to learn of the duties of this organ, yet it is known that the elimination, if not the development, of mucin in the body is controlled by it, and that its absence leads to an accumulation of this substance in the blood and tissues. The condition and appearance of the individual are very characteristic. The face is puffy, waxy white, and expressionless, with perhaps a hectic flush over the malar eminences; the tongue is enlarged; the limbs become thickened and clumsy by an increase in bulk of the soft tissues; there is often a puffy mass occupying the supraclavicular fossa, which, however, does not pit on pressure. The mental faculties are dulled, and all intellectual processes are slow; the temperature is subnormal, and the heart's action weakened. Left to itself, death will supervene from asthenia sooner or later; should the case be treated by thyroid gland or extract (half a gland, raw or lightly cooked, twice a week, or a 5-grain tabloid once or twice a day), the symptoms soon disappear, and the change from the dull, heavy condition of myxœdema to one of normal health of mind and body is almost miraculous.

Similar treatment should be employed for myxœdematous cretins, who often start growing rapidly as soon as treatment commences.

The **Parathyroid Glands** are small ovoid bodies, usually four in number; situated behind the thyroid gland, and generally near the termination of the inferior thyroid artery. Microscopically they consist of columns of epithelial cells with large nuclei, embedded in a rich capillary stroma. Spaces are often found in them containing a colloid material, which is not considered identical with that found in the thyroid vesicles. Their function is not definitely known, but their complete removal in animals causes acute convulsive attacks, together with the condition known as tetany, and death in a few days from coma. The tetany formerly ascribed to removal of the thyroid body is in reality due to disease, absence or removal of the parathyroids. It is also considered possible that the changes in the thyroid body in Graves' disease are in some way due to lesions in the parathyroids, but the exact relationship is not yet certain.

The **Thymus Gland** is an occasional source of trouble in that it persists and becomes enlarged instead of disappearing. Normally it reaches its greatest dimensions about the age of two years, and then gradually wastes so that by puberty it is represented by a mass of fatty tissue, with perhaps a few remnants of the original organ. Its persistence, and still more its enlargement, are indicated by fulness of the root of the neck, dulness over the sternum, perhaps by evidences of mediastinal pressure on the large veins, and certainly by increasing dyspnœa. A *thymic asthma,* partaking of the nature of laryngismus stridulus, has been described; but more important is the association of an enlarged thymus with generalized lymphatic hyperplasia, and a large spleen in the condition known as *status lymphaticus* (*q.v.*), which may be the cause of sudden death under anæsthetics. The thymus is also enlarged in some cases of Graves' disease. Tracheotomy is useless in the treatment of the somewhat severe dyspnœa sometimes present, and operative interference for the removal of the enlarged gland has been undertaken with success in some cases. Lymphadenoma and lymphosarcoma have also been known to affect this organ.

CHAPTER XXXIII.

SURGERY OF THE AIR-PASSAGES, LUNGS, AND CHEST.

Examination of the Upper Air-Passages.—Before the student can understand affections of this region, it is absolutely essential for him to master the use of the *laryngoscope*. This consists of a circular mirror set at an angle on the end of a metal stem, which is inserted into the patient's widely-opened mouth in such a way that it rests against, and slightly elevates, the soft palate. A beam of light is thrown into the mouth, either from an electric head-lamp on the surgeon's forehead, or reflected by a frontal mirror from a suitable source of illumination. The patient's tongue, held with a towel, is drawn well forwards so as to enable the light to reach the larynx, the image of which is seen in the mirror. Considerable practice is needed in order to attain any facility in the use of this instrument, as also to be able to recognise normal from abnormal structures. The use of cocaine to anæsthetize the fauces is in many cases indispensable. It must be remembered that the image is always inverted, so that the anterior portion of the larynx appears behind, but there is no reversal of the sides.

A new appliance has been recently employed to see the interior of the air-passages in the form of *Killian's bronchoscope* (Fig. 432). This consists of a straight tube, which can be introduced through the upper air-passages thoroughly cocainized (upper bronchoscopy), or through a tracheotomy incision (lower bronchoscopy), and can then be carried down to the bifurcation of the trachea. Smaller tubes slipped down inside the outer allow the bronchi to be examined. The interior is illuminated either directly or by reflection from a mirror. By this means foreign bodies have been extracted from a bronchus on many occasions.

Foreign Bodies in the Air-Passages.—Any part of the respiratory tract may be partially or completely obstructed by the presence of some foreign body, the effect of which may be of greater or less gravity according to the situation, character, and size of the intruding substance.

1. **In the Nasal Passages,** see p. 818.

2. Obstruction occurring **at the pharyngeal entrance to the larynx** is usually due to attempts to bolt large masses of food, which, becoming impacted, may cause immediate death. A person, eating a meal voraciously, turns black in the face and falls off his chair dead. A similar result has followed such a foolish act as attempting to swallow a billiard ball. If the obstruction is not complete, as when a plate of false teeth becomes impacted, great dyspnœa is caused, and absolute inability to swallow, the symptoms rapidly increasing owing to œdema of the submucous tissue of the glottis.

Accidents of a similar nature may occur during chloroform narcosis, an epileptic fit, or drunkenness, some such substance as a plate of teeth being dislodged from the mouth, or a mass of food being vomited, and blocking the entrance to the larynx. The **Treatment** must be very prompt, since there is no time to lose. The mouth should be forced open by the handle of a fork, or anything suitable that happens to be near, and the finger rapidly swept round the pharynx so as to dislodge the foreign body. Failing this, laryngotomy must be performed at once, and artificial respiration, if necessary, instituted. In less urgent cases there is time to remove the substance from the mouth with the assistance of a frontal mirror and suitable forceps.

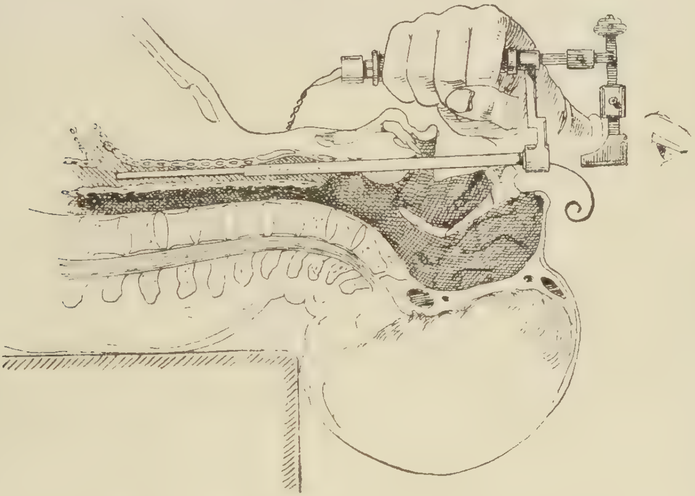

FIG. 432.—KILLIAN'S BRONCHOSCOPE IN POSITION.

The patient is generally anæsthetized, and lies on his back with the head thrown over the end of the table. After introduction of the main tube down the trachea, extension tubes can be inserted to explore the bronchi; one of the latter is shown in the above sketch reaching down to the bifurcation of the trachea.

3. **In the Larynx.**—A foreign body enters the larynx by inhalation during a deep inspiratory effort, when the glottis is widely open. Anything large is likely to be stopped above the larynx, and hence the type of foreign body found in this region consists of small coins, buttons, nutshells, or a small tooth-plate. It may cause total obstruction and immediate death, or may enter one of the ventricles, and only produce partial obstruction, as evidenced by a sudden sense of suffocation, urgent dyspnœa, and a violent attack of coughing, attended, perhaps, by vomiting, such as occurs when anything is said

to have ‘gone down the wrong way.’ The voice becomes croupy and hoarse, respirations are stridulous, and any movement of the patient may for some time bring on a spasmodic fit of dyspnœa. After a while the obstruction, which is at first partial, may become complete from œdema of the glottis, whilst perichondritis and ulceration or necrosis of the cartilages may be induced. Laryngoscopic examination should reveal the situation of the intruding body. The **Treatment** consists in attempting to remove it through the mouth with suitably curved forceps guided by a laryngoscope (endo-laryngeal method); or, failing that, a laryngotomy is performed, and the body dislodged if possible from below. Should this not be successful, thyrotomy (p. 908) must be undertaken.

4. **In the Trachea.**—To lodge in this situation a foreign body must be small enough to pass through the rima glottidis, and not too heavy, otherwise it drops into one of the bronchi; it may become impacted, if it has jagged edges, but is not uncommonly free. It may remain in one spot, only moving when the patient alters his position or coughs, and then the longer it stays, the less moveable it is, owing to its becoming embedded in mucus.

The **Symptoms** may be described as those of obstruction, irritation and inflammation. During the passage of the body through the larynx, the patient suffers from a severe attack of spasmodic dyspnœa and coughing, which may last for some time. Later on similar attacks may be induced by the foreign body being coughed up against the lower aspect of the vocal cords, and death has even resulted from its impaction in the larynx brought about in this way. The irritation of the unusual occupant of the trachea produces tracheitis, with frothy expectoration and spasmodic cough; the lower it lies, the less the irritation, the mucous membrane being apparently less sensitive as it descends from the larynx. **Treatment** consists in the introduction of a Killian's bronchoscope so that the foreign body may be seen, and by suitable forceps secured and removed. If such appliances are not available, a low tracheotomy must be performed, with a good-sized opening, and it may be possible to reach and remove the foreign body; or the patient may be inverted and the back well concussed in order to dislodge it. Failing this, the wound in the trachea must be left widely open, by inserting a wire stitch through each side of the incision and tying the ends behind the neck; very probably the body will be expelled through it during an attack of coughing.

5. To become impacted in a **Bronchus** the foreign body must be sufficiently small to pass through the rima glottidis, and heavy and smooth enough to allow of its dropping down the trachea; the most common articles met with are buttons, pebbles, slate pencils, a pin, an O'Dwyer's tube, or the inner cannula of a tracheotomy-tube. The right bronchus usually becomes obstructed, the reason for this being that although the left bronchus is more in a direct line with the trachea, yet the right is the larger, the septum between them lying to the left of the middle line A series of symptoms similar to those

already described manifests itself, viz., obstruction, irritation, and inflammation. The obstruction is twofold: immediate, as a result of the passage of the intruder through the glottis, a condition due more to spasm than to mechanical causes; and late, as a sequence of its lodgment in the bronchus. Even if the obstruction is at first partial, it soon becomes complete from swelling of the mucous membrane; for a time it is more or less valvular in character, allowing exit to air during expiration, but absolutely preventing its entrance. Collapse of that portion of the lung supplied by the affected bronchus is thus induced, as indicated by dulness and the absence of breath-sounds. Irritation and inflammation soon follow, resulting in bronchitis, the formation of a bronchiectasis, and peri-bronchial pneumonia; suppuration ensues, and the foreign body may be expelled sooner or later with a sudden gush of pus during a fit of coughing. Thus, in one case* a beech-mast was inhaled in November, 1812, and was not extruded till May, 1822, the patient having in the meantime developed all the symptoms of a bronchiectasis. Sometimes the abscess may extend through the lung substance to the pleura, setting up a localized empyema, through which, when opened, the article is expelled. In other cases the lung becomes riddled with abscesses, and the patient dies of exhaustion.

Treatment.—The position of the foreign body must be, if possible, ascertained by careful examination of the lungs, which may reveal a certain amount of collapse, whilst radiography may also be useful, and Killian's bronchoscope may permit it to be seen. A skilled laryngologist will probably be required to introduce this instrument through the mouth, but in his absence any surgeon could pass it through an incision in the trachea. The patient is advisably anæsthetized, and lies on the back with his head hanging over the end of the table. Fine tubes can be passed through the main cannula so as to enter the smaller bronchi.†

In the absence of this appliance a low and extensive tracheotomy is performed, and the bronchi are examined by a long bullet probe, suitably curved. The foreign body may thus be felt, and its removal accomplished by a delicate pair of forceps, a loop of wire, or a coin-catcher. Should it be impossible to remove it, the tracheotomy wound is left open for a time in the hope that inflammatory disturbance may loosen it, and it may be coughed up. Abscess of the lung, and localized empyema, are dealt with by incision, and it is possible that the foreign body may be removed by this means through the thoracic parietes. In several instances the chest has been opened successfully in the early stages, and a foreign body removed by direct incision into the bronchus.

Injuries of the Larynx.—Several conditions arising from traumatism of the upper air-passages have been already described—*e.g.*, fracture of the hyoid bone (p. 497), and incised wounds, as in cut throat (p. 888).

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* Mr. William Rose, senior, *Lancet*, August, 1843.

† For the employment of this method in the removal of a pin, see Sir St. Clair Thomson, *Lancet*, May 7, 1910.

Occasionally the thyroid or other cartilages may be injured or fractured by direct violence, as in garrotting, causing local pain and hæmorrhage, and possibly some obstruction to the respiration. As a rule, no treatment is required beyond keeping the patient quiet, but should symptoms of dyspnœa arise, intubation or tracheotomy must be undertaken.

Diseases of the Larynx.

The study of laryngeal diseases can only be briefly referred to here, since it is now so extensive as to require special text-books.

Acute and Chronic Laryngitis are conditions of but slight surgical interest. The acute affection arises from cold or over-exertion of the vocal apparatus, and is characterized by aphonia (loss of voice) and cough. Locally, the vocal cords are seen to be hyperæmic and swollen. The *Treatment* is rather medical than surgical, although in children intubation or tracheotomy may be sometimes required.

Diphtheritic Inflammation of the Larynx (p. 133) is usually met with as an extension of a similar affection of the fauces. It gives rise to severe dyspnœa from obstruction, and, if the condition does not yield to the injection of the diphtheritic antitoxin, will probably require intubation or tracheotomy.

Acute Œdematous Laryngitis, or œdema of the glottis, is a condition of considerable surgical importance. *Causes.*—(*a*) It is secondary either to some other laryngeal affection, such as acute catarrhal laryngitis or acute perichondritis, or more rarely to some chronic affection, such as syphilis or carcinoma; or (*b*) it may extend from inflammatory conditions of neighbouring tissues, such as the root of the tongue, or the submaxillary region—*e.g.*, in cellulitis or Ludwig's angina; or it may be secondary to a retropharyngeal abscess. (*c*) It is also not unfrequently seen in children from drinking scalding water, as from the spout of a kettle, or sometimes in adults from swallowing corrosives. (*d*) It may result from the presence of a foreign body. (*e*) It has also been known to occur as part of the general anasarca of chronic Bright's disease. *Characters.*—The folds of mucous membrane extending on either side of the epiglottis both to the root of the tongue and backwards to the arytenoid cartilages become swollen and œdematous from a serous effusion into the submucous tissue (Fig. 433). The

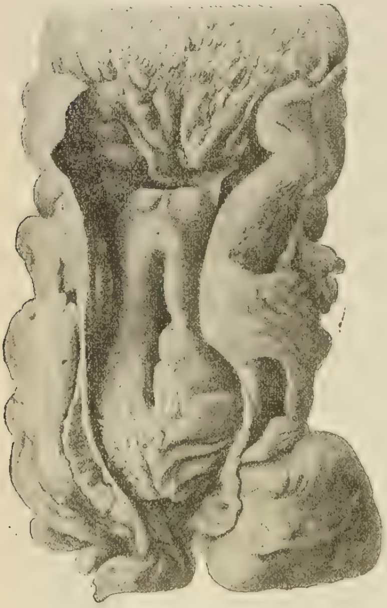

FIG. 433.—ŒDEMA OF GLOTTIS FROM BEHIND. (COLLEGE OF SURGEONS' MUSEUM.)

The base of the tongue is seen to be enlarged and swollen, and the aryteno-epiglottidean folds are œdematous, so that the entrance to the larynx is represented by a mere chink.

same condition also involves the interarytenoid fold and the false vocal cords (superior thyro-arytenoid folds), extending down as far as the true cords. The process is checked at this level owing to the absence of submucous tissue, the vocal cords consisting of elastic fibres covered merely with a layer or two of squamous epithelium. The epiglottis becomes folded laterally upon itself as a leaf, leaving only a valve-like chink, which permits of expiration although considerably checking inspiration. The *Symptoms* produced by this condition are those of mechanical dyspnœa, to which not unfrequently spasm of the glottis is superadded, and this is sometimes of sufficient intensity to destroy the patient's life. There may be also some difficulty in swallowing, owing to associated œdema of the pharynx and œsophagus, and some degree of febrile disturbance. The diagnosis is made, either by passing the finger into the pharynx, when the rigid, swollen epiglottis can be felt, or by laryngoscopic examination, when the slit-like opening of the glottis, bounded below and behind by thickened œdematous folds of mucous membrane, can be seen. *Treatment* consists in scarification of the swollen tissues below and behind the epiglottis, which can be effected after spraying the parts with cocaine by means of a suitable knife guided by a laryngoscope. The usual result is a rapid diminution of the œdema, and additional relief may be gained by inhaling steam arising from hot water, to which some tinct. benzoini co. has been added. Fomentations or ice compresses applied externally are also useful, especially the latter. In more severe cases, and especially in children, intubation may be necessary, or the air-passages may be opened below the obstruction, laryngotomy sufficing in adults, but a high tracheotomy being needed in children.

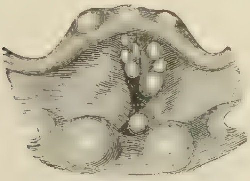

FIG. 434.—GUMMATOUS DISEASE OF THE LARYNX. (TILLMANNS.)

Small gummata are seen invading the mucous membrane of the epiglottis and front of the larynx.

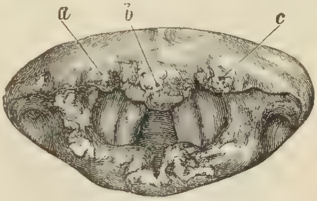

FIG. 435.—TUBERCULOUS DISEASE OF THE LARYNX, WITH EXTENSIVE ULCERATION IN FRONT AND BEHIND. (TILLMANNS.)

a, *b*, *c*, Remains of the epiglottis.

Syphilitic Diseases of the Larynx. — In the *secondary* stage, mucous tubercles or superficial ulcers occasionally form in the neighbourhood of the vocal cords, concurrently with the rash on the skin, and the formation of condylomata and mucous tubercles elsewhere. These are most likely to occur in costermongers or those who have to speak loudly, and may then lead to a good deal of thickening of the cords. Apart from such cases, it rarely causes much trouble beyond a little hoarseness. No special treatment is required, although possibly the parts, if ulcerated, may be brushed over with a solution of perchloride of mercury. In the *tertiary* period, diffuse gummatous infiltration or localized gummata may develop, giving rise to destructive ulceration, which especially affects the epiglottis and aryteno-epiglottidean folds, and may spread backwards and involve the whole glottis (Fig. 434). Inflammation of the perichondrium is likely to follow, leading to necrosis of the cartilages. Hoarseness and dyspnœa are the chief symptoms of this affection, whilst considerable obstruction may be caused subsequently by cicatrization and laryngeal stenosis. *Treatment* consists in the administration of iodide of potassium and mercury, whilst ulcers may be sprayed with perchloride of mercury solution, or dusted over with calomel or iodoform. Should urgent dyspnœa arise, tracheotomy must be undertaken.

Tuberculous Laryngitis (Fig. 435) is occasionally a primary manifestation, but is much more frequently secondary to phthisis, arising from infection of the mucous membrane owing to the constant passage over it of the sputum. It usually commences at the posterior part of the larynx in the neighbourhood of the arytenoid cartilages, as a submucous infiltration, which breaks down, and leads to typical tuberculous ulcers, similar to those occurring in other viscera (p. 182). Considerable destruction of tissue ensues, involving the whole circumference of the larynx, and even leading to perichondritis and necrosis of the cartilages. Hoarseness, cough, pain on swallowing, and perhaps a certain amount of dyspnœa, in a patient suffering from phthisis, are the chief symptoms arising from this affection, the prognosis of which is always of a grave nature. The anæmic condition of the mucous membrane is an important diagnostic sign in the early stages. *Treatment.*—As for other tuberculous affections, constitutional treatment is now mainly relied on, and for choice in a sanatorium, whilst absolute silence is insisted on. Occasionally local treatment is undertaken by the laryngologist in the form of topical applications of lactic acid, and the removal of papillary outgrowths or of the epiglottis. The earlier recognition of pulmonary tuberculosis and its more effective treatment is, however, reducing the number of cases of the laryngeal affection.

Paralysis of the Larynx is observed in a variety of conditions, but is only of surgical interest when arising from injury or division of, or pressure upon, the recurrent laryngeal nerve. It may follow the removal of a goitrous tumour or of tuberculous glands, but is most commonly seen in connection with aneurisms of the innominate or aorta, or tumours in the same neighbourhood—*e.g.*, cancer of the œsophagus, the actual pressure in the latter case being probably exercised by secondarily enlarged lymphatic glands. Paralysis from the above causes is generally unilateral, but if due to cancer both sides may be involved. The effect of complete paralysis of one recurrent laryngeal is to produce total immobility on the affected side of the vocal cord, which lies in what is known as the 'cadaveric position'—*i.e.*, midway between that in which it is placed during phonation and during inspiration. Not uncommonly the paralysis is incomplete, and then merely affects the abductor muscle (the crico-arytenoideus posticus). The *Symptoms* arising from unilateral recurrent paralysis are often slight, the voice being usually but little modified, owing to the healthy cord being capable of passing across the middle line. If, however, both sides are completely paralyzed, absolute aphonia, without dyspnœa, results; but if only the abductors are involved, the voice may be unimpaired, although severe dyspnœa is often present, and this may prove fatal unless tracheotomy is promptly performed.

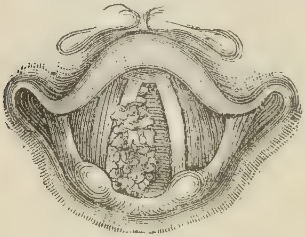

FIG. 436.—PAPILLOMATA OF THE LARYNX, SPRINGING FROM THE RIGHT VOCAL CORD. (TILLMANNS.)

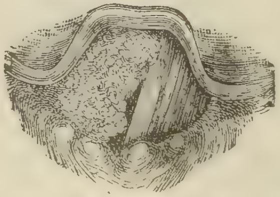

FIG. 437.—EPITHELIOMA OF THE LARYNX, INVOLVING THE RIGHT VOCAL CORD AND BASE OF THE EPIGLOTTIS. (TILLMANNS.)

Papilloma of the Larynx (Fig. 436) occurs in the form of wart-like masses, usually growing from the true vocal cords, and giving rise to considerable hoarseness and perhaps some dyspnœa. They are recognised on laryngoscopic examination, and may be removed successfully by laryngeal forceps, after the parts have been efficiently cocainized. It is recommended by some authorities to destroy the growth with a galvano-cautery, but there is always a certain liability to recur, and thyrotomy may be required in a few cases to establish a radical cure.

Epithelioma Laryngis occurs in patients over forty, originating as a papillary overgrowth, usually near the base of the epiglottis, or from the true or false cords (Fig. 437). The tumour gradually spreads, both superficially and deeply, and may invade the cartilages, giving rise to necrosis. At a later stage it extends beyond the limits of the larynx, attacking the base of the tongue, œsophagus, and even the lateral walls of the pharynx. As long as the disease is strictly limited to the larynx (intrinsic), the growth is often unilateral, causing hoarseness and aphonia, together with an irritable cough and the expectoration of blood-stained muco-pus, which may be horribly offensive; it is associated with but little tendency to affection of lymphatic glands. When, however, the growth has extended to surrounding structures (extrinsic), lymphatic enlargement follows, and the disease runs its usual course, destroying life by dyspnœa and exhaustion. Pain is often a most distressing symptom, being referred either to the larynx or pharynx, or, according to Ziemssen, not unfrequently to the ear. *Treatment.*—In the early stages thyrotomy and efficient curetting and cauterization will probably bring about a cure. Later on, removal of one or both halves of the larynx, together with the affected glands, will be required, and the operation may even include parts of the tongue and pharyngeal wall. Where, however, the disease has spread extensively, its total extirpation is rarely practicable, and all that can be done is to treat symptoms as they arise, and perform tracheotomy when necessary.

Acute and Chronic Perichondritis are affections of the perichondrium, usually ending in the formation of an abscess and in necrosis of the cartilage involved. The *acute* variety is pyogenic, and due to traumatism or to auto-infection, following acute fevers, such as typhoid. The patient complains of severe pain and tenderness over the larynx, with fever, dysphagia, and hoarseness. Dyspnœa results from swelling of the mucous membrane, and œdema of the glottis may follow. An abscess may point internally or externally, and on opening it the cartilage will usually be felt bare and perhaps necrosed. *Treatment* in the early stages consists in fomentations; but when the affection is producing dyspnœa, and an external swelling is present, it is well to cut down on the cartilages from outside. Should this fail to relieve the dyspnœa, a tracheotomy will be required. The *chronic* variety is more often due to tubercle, syphilis, or carcinoma: in it an abscess forms more slowly and with less constitutional disturbance, but necrosis ensues none the less. When the abscess points externally, it should be opened from outside, but sometimes in these cases it is possible to deal with it from within. When a well-marked sequestrum is present, it must be removed by an external incision, and if need be thyrotomy must be undertaken. Distortion or stenosis of the larynx is not an unusual sequela, possibly necessitating the perpetual use of a tracheotomy-tube.

Operations upon the Air-Passages.

1. **Subhyoid Pharyngotomy** was devised by Malgaigne, in order to provide access to the upper parts of the larynx in the treatment of foreign bodies or tuberculous disease. A transverse incision is made through the thyro-hyoid space, the pharynx is opened, and the epiglottis detached from the base of the tongue (Fig. 438, I.). It is a proceeding that is seldom undertaken, and scarcely necessary.

A much more satisfactory procedure is **Trans-hyoid Pharyngotomy,*** in which the hyoid bone is divided in the middle line through a vertical incision extending from the symphysis menti to the thyroid cartilage. The pharynx can then be opened either above or below the level of the hyoid bone, and the back of the tongue, the posterior wall of the pharynx, or the upper part of the larynx freely exposed. A preliminary tracheotomy is, of course, necessary. We have utilized this operation both for the removal of an epithelioma of the epiglottis and back of the tongue, and for enucleating a sarcoma of the posterior pharyngeal wall, and were much pleased with the approach given to these parts.

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* See *Revue de Chirurgie*, May, 1900

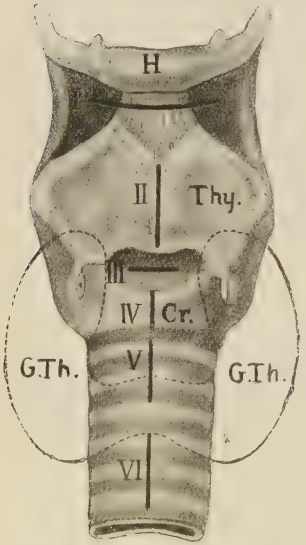

FIG. 438.—OPERATIONS ON THE AIR-PASSAGES.

I., Subhyoid pharyngotomy; II., thyrotomy; III., laryngotomy: IV., cricotomy; V., high tracheotomy; VI., low tracheotomy; H., hyoid bone; Thy., thyroid cartilage; Cr., cricoid; G.Th., thyroid body.

2. **Thyrotomy** (Fig. 438, II.) consists in a vertical section of the thyroid cartilage, and may be required for the removal of foreign bodies or tumours, or for the radical treatment of laryngeal tuberculosis or cancer. Tracheotomy is performed as a preliminary measure, and the trachea plugged around the tube. An incision is then made in the middle line of the neck, extending from the hyoid bone to the cricoid cartilage. The cricothyroid ligament is clearly defined and severed transversely, and the thyroid cartilage accurately divided by a knife, cutting-pliers, or fine saw. The lateral halves are separated, and the intralaryngeal portion of the operation proceeded with. When closing the wound, the greatest care must be taken to bring the sides together in such a way that the vocal cords are exactly opposite each other, or phonation will be considerably impaired. This is best ensured by making a horizontal nick across the front of the cartilage before dividing it.

3. **Extirpation of the Larynx (Laryngectomy)** is always a serious operation, which is never undertaken except for malignant disease. According to the site of the tumour, the removal may be partial or complete: for a growth strictly limited to one side, extirpation of that half will suffice, and admirable results have followed such treatment, distinct speech remaining; but if the whole larynx is removed, although the patient is subsequently able to whisper, phonation is impossible without mechanical assistance, whilst if the disease has extended beyond the limits of the larynx, operative interference is rarely successful.

Operation for Complete Extirpation.—An incision is made in the middle line of the neck from the hyoid bone to below the cricoid cartilage. The soft parts are stripped from the lateral aspects of the thyroid cartilage with raspatories, the sterno-hyoid, sterno-thyroid and thyro-hyoid muscles being divided at their insertions, and the isthmus of the thyroid body being divided between ligatures if necessary. The crico-tracheal membrane is then cut through, or the trachea itself is divided on the slant, and either fixed in the lower angle of the wound, or a fresh incision is made a little lower down, and through this it is drawn and stitched flush to the skin. At this stage it is often wise to divide the thyroid cartilage longitudinally, so as to ascertain exactly the extent of the disease. If it is limited to the larynx, removal is perhaps best effected from below upwards, a transverse incision at the level of the hyoid bone, and extending between the two sterno-mastoid muscles, being required to facilitate this proceeding. The connections of the constrictor muscles to the cricoid and thyroid cartilages are severed by scissors, and the larynx can now be drawn forwards and separated from the anterior pharyngeal wall, which must be left intact if possible. The thyro-hyoid membrane and base of the epiglottis are cut through, and the final steps of the operation consist in clearing the superior cornua of the thyroid and dividing the lateral thyro-hyoid ligaments. The operation is not particularly difficult or dangerous, provided that the surgeon keeps close to the larynx, and that the disease does not extend beyond its limits. When other structures such as the base of the tongue have been invaded, these steps must be modified so as to secure, if possible, complete removal of the disease. The upper portion of the œsophagus has even been included in the scope of the operation.* Finally, the rent in the mucous membrane of the pharynx is closed by sutures, the divided muscles are drawn together, and the incisions in the skin closed; if this be practicable, healing by first intention may follow, the air-passages being thereby entirely separated from the pharynx. Of course, phonation is lost completely, but the patient can whisper, and by means of suitable apparatus this can be magnified and utilized so as to be of service. In not a few cases, however, it is impossible to close the wound completely, and then it must be packed and allowed to heal by granulation.

If the œsophagus is encroached on in the operation, it is sometimes feasible to restore continuity between the pharynx and the lower end by means of a flap of skin turned in, or the wound is allowed to granulate, and a rubber funnel passed so as to prevent cicatricial contraction, and to allow the passage of food. In other cases a communication can be established between a pharyngeal fistula above and a gastrostomy wound below, and food can be carried into the stomach through an external rubber œsophagus worn under the clothes.

If the disease is limited to one half of the larynx, the thyroid cartilage is cleft in the middle line, and the operation confined to the affected side.

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* Arthur Evans, *Transactions of the Royal Society of Medicine*, Clinical Section, vol. iii., p. 44, and vol. iv., p. 142.

4. **Laryngotomy** is rarely undertaken except for the relief of dyspnœa arising from some sudden obstruction to the respiration, and is thus to be looked on as *an operation of urgency*. It is required in cases where the entrance to the larynx is obstructed by a foreign body, for spasm of the glottis, or for accumulations of blood in the neighbourhood of the larynx during an operation. It is readily performed by making a vertical incision over the situation of the crico-thyroid membrane, which is then divided transversely along the upper border of the cricoid cartilage (Fig. 438, III.), the sterno-hyoid muscles being, if necessary, drawn aside, and a tube inserted. Possibly the small crico-thyroid artery arising from the superior thyroid may require a ligature. In cases of great urgency, a simple transverse incision may be made with a penknife, and the larynx opened, the margins of the wound being held aside by a hairpin, or by the handle of a scalpel turned edgeways, whilst a toothpick will serve temporarily as a cannula. Whenever there is time to operate deliberately, a high tracheotomy is the better practice, since a tube inserted through the crico-thyroid space gives rise to considerable irritation, and the voice may be subsequently impaired by the contraction of the cicatrix. A special laryngotomy-tube is required, the lumen of which is not circular, but oval and flattened from above downwards.

In children, where there is but little space, the proceeding may be modified by division of the cricoid cartilage, and even of the first ring of the trachea, constituting what is known as *cricotomy* or *laryngo-tracheotomy* (Fig. 438, IV.).

5. **Tracheotomy.**—The trachea usually consists of from sixteen to twenty rings, of which six or seven are situated above the sternum. The isthmus of the thyroid body generally covers the third and fourth rings, and the trachea may be opened either above or below it, or even sometimes behind, the isthmus being, if necessary, divided. Tracheotomy is required in any condition in which there is serious obstruction to the respiration—*e.g.*, various forms of laryngitis, and especially for œdema of the larynx or diphtheria; for stenosis, tumours, and some forms of paralysis of the larynx; occasionally for the removal of foreign bodies, either in the larynx, trachea, or one of the bronchi; or for compression of the larynx or trachea by external tumours, such as a malignant thyroid body. It is also undertaken as a preliminary measure in operations on the mouth, tongue, pharynx, or larynx, in which there is any likelihood of asphyxia or secondary septic pneumonia, owing to the entrance of blood or septic discharges into the air-passages. As a general rule, the high operation (that is, above the isthmus of the thyroid body) is to be preferred, but under special circumstances it may be advisable to open the trachea lower down. The risk attaching to the high operation is considerably less than to the low, but the opening is made nearer to any disease which may exist in the larynx. For the removal of foreign bodies from the bronchi or trachea, the low operation should always be employed.

The *high* operation (Fig. 438, V.) is performed as follows: The patient is placed on the back, with a sandbag or pillow beneath the neck, so as to throw the head backwards and put the structures on the stretch, and with the shoulders somewhat raised. Anæsthesia may be induced by chloroform, but it is unnecessary, and indeed unwise, to push the anæsthetic, since it is only needed for the division of the skin; where the dyspnœa is considerable, it is better to employ local anæsthesia by the infiltration method (*q.v.*). The head is held exactly in the middle line, and the surgeon feels for, and identifies, the cricoid cartilage. The incision extends from this structure downwards for about 1½ inches. The superficial fascia is divided, and the interval between the sterno-hyoid muscles made out, so as to enable them to be separated one from the other. The edges of the wound are drawn aside by blunt hooks, which should both be held by one assistant, so as to ensure equable traction.

The isthmus of the thyroid body may now be seen, and, if projecting unduly upwards, should be pushed down after the fascia along its upper border has been transversely incised. The trachea is next clearly exposed by using the handle of a scalpel and dissecting forceps, and should be fixed and steadied by inserting a sharp hook into the lower border of the cricoid cartilage. The wound is freed from blood as far as possible, and the trachea opened by inserting the point of the scalpel and dividing two of the rings from below upwards. A deep inspiration is usually taken at once, followed by a severe fit of coughing, and if the operation is undertaken for diphtheria the surgeon must be careful not to let any membrane which may then be expelled enter his eyes, nose, or mouth. The insertion of the tube is in many cases easy, in others a matter of some difficulty; a good deal depends upon the age of the patient, the urgency of the symptoms, and the depth from the surface at which the trachea lies. Anything which suffices to separate the lips of the tracheal incision—*e.g.*, the handle of a scalpel introduced and turned, a couple of hooks, or dressing forceps—will form an efficient guide for this purpose. The breathing soon becomes quiet and regular, and the tube is fixed in position by tapes passed through lateral openings in the face-plate, and tied round the neck. No dressing is required for the wound except a few layers of gauze beneath the plate.

Low tracheotomy (Fig. 438, VI.) is performed in almost precisely the same way, except that the incision extends further downwards, even reaching to the episternal notch, although the deeper part of the wound should never pass beyond a finger's breadth above the sternum, for fear of opening that portion of the cervical fascia which is prolonged downwards to the pericardium, or of wounding the left innominate vein. The superficial layers of fascia are divided, and the sterno-hyoid and sterno-thyroid muscles drawn to either side by retractors. The inferior thyroid veins then come into view, and may cause trouble if they are distended with blood, as is so frequently the case in patients suffering from dyspnœa. They must be held aside by hooks, or divided between ligatures, and the deep layer of fascia behind them incised so as to expose the trachea, which is cleared, fixed, and opened in the same way as described above.

Many different forms of *tracheotomy-tube* have been used from time to time, but the essential elements of which it consists are a double cannula, the inner portion of which can be readily removed and cleansed; it should always be longer than the outer, in order to prevent any plug of mucus being left within the outer tube on removal of the inner. A face-plate, or some similar contrivance, is attached to the outer cannula, in order to fix and steady it. One of the best is that known as *Parker's tube* (Fig. 439), which has a handy introducer and is perhaps of a better shape than most of the others, following more closely the direction of the trachea. The *bivalve tube* is another useful instrument; the outer sheath consists of two lateral portions, attached to a single face-plate, and these can be pressed together, and hence with care easily inserted through the incision in the trachea. The surgeon must see that both limbs enter the trachea, as trouble has arisen from one limb passing outside, and the other inside, thus hindering the introduction of the inner tube. Whatever variety of tube is preferred by the surgeon, it is essential to have several sizes to hand, as the calibre of the trachea varies much in different patients. In cases of preliminary tracheotomy, undertaken to prevent the entrance of blood during operations, *Hahn's tube* may be used with advantage; in this the outer cannula is covered with a layer of compressed sponge which swells up from the absorption of moisture, and thus occludes the lumen of the trachea. *Trendelenburg's tampon* is recommended by some for the same object; the outer tube is here ensheathed with a thin indiarubber casing, which can be distended with air at will.

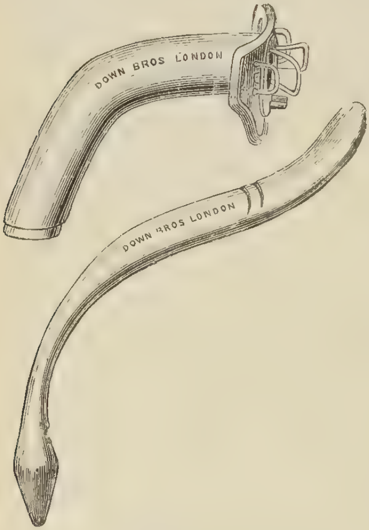


FIG. 439.—PARKER'S TRACHEOTOMY-TUBE AND INTRODUCER. (DOWN BROTHERS.)

Difficulties and Dangers of the Operation.—Although the above description might lead the student to suppose that tracheotomy is an easy operation, this is by no means always the case, partly owing to the fact that it frequently has to be undertaken in a hurry, with perhaps inefficient assistance, and in a bad light, and partly owing to the intense vascular engorgement of the structures met with. A cool head and a steady hand are in such cases of infinitely more value to the operator than the most perfect anatomical knowledge. The following are the chief conditions which may lead to mistakes and accidents:

(1) The administration of any general anæsthetic is often inadvisable in semi-asphyxiated patients, since complete *cessation of respiration* may be caused thereby, possibly from spasm of the glottis, Local anæsthesia by the infiltration method should be relied on in such cases, and the employment of β-eucaine and adrenalin has been most satisfactory.

(2) It is *not always easy to find the trachea*, especially in the necks of fat children, or where it is hidden by an unduly large thyroid isthmus, or possibly by the projection of the thymus gland into the neck. It is here most essential to remember the old adage, *In medio tutissimus ibis*, although occasionally the trachea may be displaced from the middle line by some external growth, and can then only be found by careful exploration with the finger.

(3) *Hæmorrhage* is generally troublesome. It is usually venous in character, arising either from the anterior jugular vein or from the inferior thyroid plexus. If possible, it should be controlled by pressure-forceps before opening the trachea; but this is not absolutely necessary in urgent cases, since it usually ceases as soon as easy respiration through the tube has been established. The presence of the left innominate vein in front of the trachea must not be forgotten, although it but rarely reaches above the sternum. In about 8 per cent. of all subjects an arterial twig (the *thyroidea ima*) courses upwards from the innominate artery along the trachea, to reach the isthmus of the thyroid body; if divided, it can be easily secured and tied. Should much blood be inspired, it may determine the occurrence of septic pneumonia at a later date.

(4) The possibility of the *entrance of air into veins* must not be overlooked, although it is an uncommon accident, since the intravenous pressure is usually increased.

(5) Not unfrequently considerable mischief has been done by an *incautious use of the knife*, especially if the operator forgets to fix the trachea with a sharp hook before opening it. The knife should always be entered with its back towards the episternal notch, and the incision made from below upwards. In a child the trachea is small; and if it is moving rapidly up and down, as happens in urgent dyspnœa, or if the child is restless, and not completely under the influence of an anæsthetic, the difficulty is manifestly increased. Many accidents have happened from this cause—*e.g.*, wounds of the large veins or arteries of the neck, or even of the œsophagus or bodies of the vertebræ!

(6) As soon as the trachea is opened or an attempt made to introduce the tube, a severe fit of *coughing* is induced, which is sometimes so prolonged as to interfere with the introduction of the tube. Under such circumstances the incision in the trachea may be opened up with a tracheal dilator, or by a pair of sinus forceps, and a few drops of cocaine swabbed over the mucous membrane.

(7) The *introduction of the tube* is a matter of no difficulty if the

surgeon takes the precaution of not removing the hook until this is satisfactorily accomplished. Many mistakes have followed the non-observance of this rule; thus, the tube has missed the trachea altogether and passed into the fascial interspace in front, as also to one or other side; as before mentioned, the outer portion of a bivalve tube has often been passed with one limb within the trachea and the other outside. A very dense diphtheritic membrane has also been a cause of difficulty, in that, although the tube has been really passed into the trachea, it has not penetrated the membrane, and thus has hindered rather than helped the breathing. In all cases of diphtheria the trachea should be freely opened, and the interior carefully examined by separating the lips of the incision before attempting to insert the tube. In order to prevent the downward passage of the membrane, some surgeons have recommended that the lower portion of the larynx should be carefully stuffed with antiseptic gauze above the tube.

After-Treatment.—The patient is placed in bed, in a room kept at a uniformly warm temperature (75° F.), the air being moistened by the steam issuing from one or more bronchitis kettles, so as to make up for the absence of nasal and oral respiration. Draughts are excluded by curtains, and nothing should be placed over the entrance to the tube, so that respiration may not be hindered, nor the expectoration of mucus, false membrane, etc., prevented. One of the most frequent sources of extension of diphtheria to the lungs, or of septic pneumonia, is the re-inspiration of material which has been coughed out upon a portion of muslin or gauze, placed with excellent intentions over the mouth of the tube. A nurse should be in constant attendance on the patient, in order to wipe away all such material *as it is expelled.*

The inner portion of the tube is removed by the nurse, and cleaned two or three times a day, any inspissated mucus upon it being readily removed by the use of a solution of bicarbonate of soda (20 grains to 1 ounce). The outer tube is also removed once a day for cleansing purposes, but only by the medical attendant. Should the respiration become impeded by a collection of mucus in the trachea, a fine feather may be passed down the tube in order to clear it, but *never in diphtheritic cases*; for such a contingency special suction-tubes have been devised. Attempts have been made to clear the passages by applying the lips to the tube, and removing the block by suction; such is, however, quite unjustifiable, and several promising house-surgeons have in this way lost their lives.

The period for which the tracheotomy-tube is kept in position varies in different cases, but its removal should always be undertaken at as early a date as possible, for fear of leading to impairment of the voice. In order to prevent this, the inner cannula is made with a hole in the upper end, so that part of the air may pass through the larynx. If the patient can then breathe comfortably when the finger is placed over the entrance to the tube, its presence is no longer necessary.

After-Complications of Tracheotomy.—(*a*) The tube may give rise to ulceration of the trachea if it is not correctly shaped. Thus, if too much curved, it tends to irritate the anterior wall, and cases are known in which it has caused death by perforation of the left innominate vein. If insufficiently curved, the posterior wall may become affected, and the œsophagus laid open. In cases where a tracheotomy-tube has to be worn for a long time, it is advisable to make use of indiarubber tubes.

(*b*) Various forms of septic trouble may arise in the wound, leading to cellulitis and even secondary hæmorrhage; this is especially dangerous in the low operation, since the inflammation may extend to the mediastinal tissues. In cases of diphtheria the wound may also become affected with the disease.

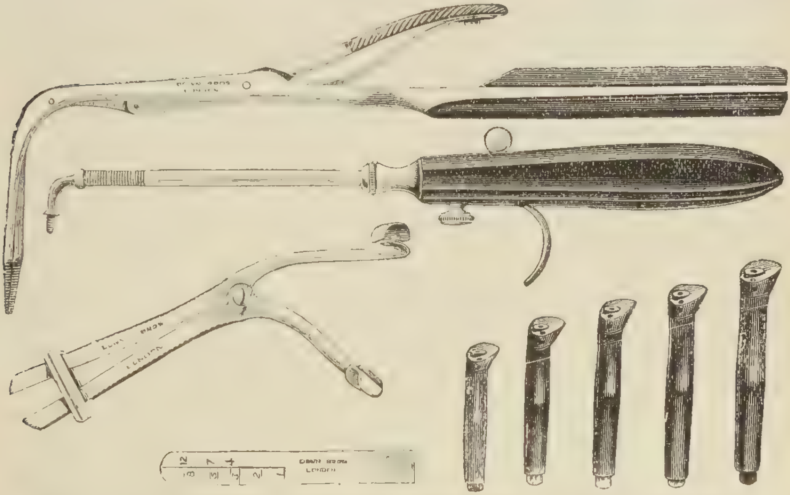


FIG. 440.—O'DWYER'S INTUBATION APPARATUS. (DOWN BROTHERS.)

The cannulæ are seen below on the right; a hinged inner tube passes throughout the length of each, and the upper end of this is screwed to the extremity of the introducer seen in the middle; when it has been inserted into the larynx, the trigger of the introducer is drawn, and by this means the inner tube is loosened and can be easily removed, leaving the cannula in position. To extract the tube, the rectangular forceps represented at the top is utilized; the point of the forceps is inserted into the top of the cannula, and then by opening the blades the cannula is fixed and can be withdrawn. A useful type of unilateral gag is also represented, and a small gauge to indicate the size of cannula required at different ages.

(*c*) Inflammation of the trachea, bronchi, and lungs may result either from the entrance of cold, or unmoistened air, or from the inspiration of septic or diphtheritic material.

(*d*) Difficulty is sometimes experienced in leaving off the tube, owing to the presence of granulations obstructing the lumen of the trachea, or to stenosis of the trachea or larynx, or even to paralysis of the abductor muscles, especially in diphtheritic cases. The trachea may also be kinked, and its calibre thus diminished, by cicatricial union of the skin and mucous membrane. The diagnosis of the cause at work in any particular case can only be made by laryngoscopy, or careful examination of the wound and upper portion of the trachea. Granulations may be scraped away under an anæsthetic or destroyed by caustics; stenosis of the larynx is overcome by dilatation with an O'Dwyer's tube; stenosis of the trachea may require excision of the affected segment, whilst laryngeal paralysis must be treated by the use of electricity.

(*e*) Finally, it should be remembered that if a patient (and especially a boy) is condemned to the perpetual use of a tracheotomy-tube, he must be warned of the possibility and danger of water getting into the trachea and his being drowned thereby. Certainly one death has occurred from a boy bathing under these circumstances!

6. **Intubation of the Larynx** is a means of treating laryngeal obstruction which has been introduced in order to obviate the risks present in tracheotomy. It consists in the passage through the mouth of a suitably curved tube into the larynx, by means of a specially contrived introducer. The best patterns to employ for the purpose are those known as O'Dwyer's tubes (Fig. 440). The lower end of the cannula is oval, and not circular, and passes between the cords into the larynx, whilst the upper enlarged end lies over the entrance; it requires changing frequently in order to prevent erosion of the mucous membrane. It has been used with considerable success in cases of œdema of the glottis and laryngeal stenosis, but is scarcely to be recommended for diphtheria, owing to the risk of carrying the false membrane down with it. The actual mortality in a large series of cases of diphtheria has been proved to be much the same as for tracheotomy—viz., about 30 per cent.

Affections of the Ribs and Sternum.

Several forms of **Fracture** have been already described (pp. 498 and 499).

Acute Suppurative Inflammation of these bones is very unusual. Occasionally an acute osteo-myelitis, running its usual course to necrosis, occurs in children; but the most common cause is typhoid fever (p. 568). The affection is generally of a subacute type, and a more or less extensive cario-necrosis results. The special feature of the disease is the tendency of the bacilli to remain in a latent condition in the tissues, so that it is difficult to ensure a perfect cure apart from complete extirpation of the affected portion of bone. Mere scraping is rarely sufficient.

Syphilitic Disease is more common in the sternum than in the ribs. The upper part of the *sternum* is that usually involved, and the affection is characterized by a formation of gummata in and upon the bone, which erode it, usually in a pitted fashion, and may cause necrosis. The usual treatment with iodide of potassium and mercury is required, and sequestra will need to be removed. In connection with the *ribs*, syphilis appears as a tertiary periostitis or perichondritis. A fusiform swelling is produced in the course of a few weeks, with but little pain or tenderness; it may easily be mistaken for tuberculous disease or a new growth, but the history of the patient may help one to a correct diagnosis, or the administration of iodide of potassium will clear it up.

Tuberculous Disease affects the ribs much more frequently than the sternum. In the *ribs*, it may arise primarily as an osteomyelitis, implicating an extensive portion of the medulla; but it is not unfrequently secondary to tubercle of neighbouring parts, *e.g.*, the spine or pleura, and then commences beneath the periosteum; several ribs may be involved at the same time. The disease is most commonly seen in young people, and affects either the middle of the rib or the costo-chondral junction. The usual manifestations of tubercle in bone are seen, giving rise to expansion of the bone, or to caries or necrosis, and suppuration is common. The abscess cavity may be mainly external to the ribs, but is not unfrequently hourglass-shaped, a narrow neck connecting the cavities which lie inside and outside the chest. *Treatment* in these cases must be of a radical type. Mere scraping and disinfection are often inefficient, and the complete removal of an extensive portion of the rib and of the abscess cavity attached to it is required.

In the *sternum* tubercle runs its usual course, and may present an abscess which points either in front near the middle line, or may come forwards from behind through an intercostal space. The treatment consists in cutting or scraping away the abscess wall, and in dealing with the bone; it may be necessary to remove some portion of it by gouge or cutting-pliers, in order to gain access to the primary focus.

Tumours of the ribs and sternum are usually chondromata or chondro-sarcomata; perhaps the former are a little more common in the ribs, the latter in the sternum. The patient complains of but little pain, and therefore the cases are usually late in coming under observation. In time the growth becomes adherent to the pleura, and the lung itself may be invaded. In the early stages it is sometimes possible to remove them, although the lung is liable to collapse unless special precautions are taken (p. 925).

Surgical Affections of the Lungs and Pleural Cavities.

Non-penetrating Wounds of the Lungs result from violence applied to the chest, with or without fractures of the ribs, and consist either of laceration or contusion.

Contusion of the Lung often follows some injury which is not sufficiently severe to fracture the ribs. The symptoms produced are severe pain in the side, with perhaps temporary shock and slight hæmoptysis. Some traumatic inflammation follows, both of the lung and of the pleura, as indicated by loss of resonance and possibly friction sounds. The *treatment* consists in keeping the patient quiet in a warm room, at the same time carefully regulating the bodily functions. Pain is often relieved by strapping the side of the chest.

Laceration of the Lung is usually secondary to fracture of the ribs, especially if due to direct violence. The severity of the symptoms necessarily varies with the character and extent of the injury. The patient suffers from marked shock in bad cases, associated with pain in the side and dyspnœa. Evidences of *hæmorrhage* soon follow, either in the form of hæmoptysis or hæmothorax. If the wound is a small one, the patient complains of an irritating cough, and brings up a good deal of blood-stained frothy mucus; but if the laceration is extensive, involving some of the larger pulmonary trunks, a quantity of pure blood may be ejected, even leading to death from syncope, or from asphyxia, owing to the blood filling the larger bronchial tubes. *Hæmothorax* may also be so excessive as to cause the patient's death from compression of the lung. It results in a gradually increasing area of dulness extending from below upwards, together with loss of breath-sounds and vocal fremitus, coming on soon after the injury without signs of inflammation, but with the constitutional signs of hæmorrhage.

Owing to the laceration of the pulmonary vesicles, air tends to escape either into the pleural cavity, giving rise to the condition known as pneumothorax, or into the cellular tissue of the body, constituting surgical emphysema. *Pneumothorax* is always associated with more or less collapse of the lung, and, if complete or produced suddenly, is almost certain to lead to considerable interference with respiration, and possibly to severe dyspnœa, or even orthopnœa. A slight degree of pneumothorax, or a complete one, if produced slowly, and if the other lung is healthy and no strain is thrown upon it, has but little functional result. The air which finds its way into the pleura in connection with a ruptured lung, having been filtered through the pulmonary alveoli, is free from organisms, and hence does not cause suppuration or putrefaction of the blood-clot present, unless bronchitis or some other suppurative condition has existed previously. The physical signs of pneumothorax consist in a high-pitched tympanitic note on percussion, and on auscultation amphoric breathing and possibly metallic tinkling. As soon as the wound in the lung commences to heal, the amphoric sounds disappear, the effused air is absorbed, and the lung gradually expands—a process which may take four or five days. If blood is also present in the thorax, a condition of hæmo-pneumothorax is produced, recognised by a splashing or succussion sound heard on shaking the patient. *Surgical Emphysema* almost always indicates a wound of both pulmonary and parietal layers of the pleura, which are slightly separated by air, constituting a localized pneumothorax. At each inspiration a fresh amount of air enters this cavity, and is expelled into the areolar tissues through the parietal wound at each expiration, being forced perhaps to a considerable distance from the spot where it commences, or even spreading over the whole body. It is of no serious significance, unless extensive, disappearing rapidly after the wound in the lung has commenced to heal, thus occluding the opened pulmonary alveoli. It is recognised by the parts becoming swollen and puffy, and giving a sensation of fine crackling crepitus when the hand is pressed over them. Occasionally emphysema may arise as an *interstitial* condition, when the parietal pleura has not been injured, the air escaping from the alveoli along the interalveolar connective tissue into the root of the lung, and then appearing first at the lower part of the neck. This is often a condition of grave import.

Such are the ordinary phenomena observed in the early stages of a ruptured lung. The effects subsequently produced consist in a localized traumatic pleuro-pneumonia, associated with slight elevation of the temperature, possibly rusty sputum, and often severe dyspnœa. In the worst cases death may result from asphyxia.

Penetrating Wounds of the Lung, due to direct injury and often associated with fracture of the ribs, are followed by very similar effects. The story is modified, however, by the fact that the external wound in the chest wall allows of the exit of blood, arising either from an intercostal artery, the internal mammary, or from the wounded lung, whilst it also permits the entrance of bacteria with the air into the pleural cavity, and thus may change the resulting pleuro-pneumonia from a simple to an infective inflammation. Empyema is consequently a frequent sequela, whilst the inflammation of the lung may be of a spreading nature, possibly terminating in suppuration or gangrene. Surgical emphysema is also induced by air being sucked into the wound during inspiration, and failing to escape during expiration, owing to the lips of the wound falling together. This condition may ensue even when the lung itself has not been damaged.

Treatment.—When the rupture of the lung is due to a subcutaneous injury, the patient should be kept quiet in a warm room, and the side strapped. The compression of the chest wall must sometimes be omitted in patients where the irregular ends of fractured ribs, broken by direct violence, are driven inwards, for fear of increasing the mischief in the lung.

Persistent hæmoptysis must be treated by keeping the patient absolutely quiet, and allowing him to suck ice continually. Ergotin may be injected hypodermically, or a mixture of ergot, opium, and sulphuric acid administered; the opium is especially needed when great restlessness and irritability are present. Lactate of calcium may also be given by the rectum. Stimulants are necessarily contraindicated, for fear of again starting the bleeding. Hæmothorax rarely needs special treatment, since the blood soon clots and is readily absorbed; but occasionally it may be so abundant as to compress the lung and lead to dyspnœa, and under these circumstances it may be necessary to aspirate the chest, or if that fail (as is not unlikely) to open up the pleural cavity and remove it. This must never be undertaken until sufficient time has elapsed to permit of thrombosis in the wounded vessels. Decomposition of the blood in the pleural cavity occasionally happens even in non-penetrating injuries, the bacteria reaching it either from the blood or from the torn bronchi; the suppuration and fever thereby induced necessitate the opening and drainage of the pleural sac.

Simple pneumothorax seldom requires surgical treatment, since the imprisoned air is quickly absorbed, and the lung re-expands; should this not occur, and if severe dyspnœa is present, it may be advisable to remove the air by aspiration. This may sometimes fail, or the air may re-collect, and then the chest wall must be opened so as to give exit to the air. It is impossible for the lung to re-expand against the pressure of air confined in the chest; when an opening is made, the air can be driven out by a vigorous expiratory movement, such as coughing, which also forces air from the healthy lung into the wounded one when the glottis is closed.

Temporary dyspnœa may be overcome by the inhalation of oxygen; but when of a more decided character, and not due to any condition which can be removed, the essential treatment is to diminish the blood-pressure, and thus decrease the amount of blood carried to the uninjured lung, so as to enable it to cope with the work of blood-aëration. This may be accomplished by administering antimonial wine (10 to 15 minims every four or six hours) combined with full doses of liquor ammoniæ acetatis; but in urgent cases, where the patient is becoming cyanosed, and life is threatened by asphyxia, venesection must be adopted. The blood is withdrawn from the arm rapidly and freely, and as it flows the dyspnœa passes off. This may be repeated once or twice in addition to the use of the medicine before the full effect is obtained and respiration becomes unembarrassed.

The treatment of *penetrating wounds of the thorax*, involving the lung, is always a matter of considerable difficulty. The skin around the opening is carefully purified and shaved, if necessary, and a limited exploration of the wound is permissible, so as to determine whether portions of the clothing have been carried in, or a rib comminuted; all such loose fragments must be removed, as also any penetrating foreign body, such as a bullet, if readily accessible. The greatest gentleness must, however, be employed, and no attempt made to pass a probe into the pleural cavity, since it is easy to dislodge clots lying in the pulmonary tissues, and thereby restart the bleeding. If the wound itself needs sterilizing, it is perhaps best to touch it over with pure carbolic acid or tincture of iodine rather than to irrigate it, and then a dry antiseptic dressing is applied without drainage.

Immediate operative interference is only required under two conditions, viz., for hæmorrhage and for hernia of the lung.

Hæmorrhage after a penetrating wound of the chest wall may be derived either from a vessel in the parietes (intercostal or internal mammary), or from the lung itself. The recognition of the source of the bleeding is not always easy, but it is probably of *parietal* origin (*a*) if it is unaccompanied by hæmoptysis; (*b*) if it increases obviously at each systole; and (*c*) if it can be controlled by digital compression. The treatment of bleeding from the internal mammary and intercostal vessels has been already indicated (p. 297).

Pulmonary hæmorrhage is not so readily controlled, and various plans have been recommended. Probably the best method consists in keeping the patient absolutely quiet in the horizontal position, applying cold to the side, and giving hæmostatics, as indicated above for non-penetrating wounds. The effect of this will be to cause the blood in the pleural cavity to clot, and this acts as a tampon to the affected viscus; firmly plugging the external wound may limit the loss of blood and determine coagulation more quickly. In bad cases the hæmorrhage may cease only when the patient is in a condition of profound collapse; intravenous or hypodermic infusion of hot saline solution may then suffice to tide over the period of danger and lead to a successful result.

The question of opening the thorax by turning up a large flap of the chest wall (including portions of several ribs) so as to deal directly with the injured lung has been raised of recent years, and cases in which it has been undertaken have been recorded. Further experience will probably decide that such a procedure is quite unjustifiable except in very unusual circumstances.

The later treatment of these cases is much the same as for simple non-penetrating injuries. Should symptoms of suppurating pleurisy follow, the wound must be freely opened, a portion of rib being excised, if necessary, and the cavity drained, as for empyema.

Hernia of the Lung, or pneumocele, is a rare condition in which a portion of the lung protrudes through an opening in the thoracic parietes beneath the uninjured skin. It may occur suddenly, as the immediate consequence of a laceration of the intercostal muscles and pleura, or more gradually, being then due to the yielding of a cicatrix. It is most usually seen about the fifth intercostal space, but has been known to occur in the root of the neck from a lesion in the dome of the pleura. It is recognised by the appearance of a rounded swelling, increasing in size on coughing or making expiratory efforts, and possibly disappearing entirely on holding the breath. It imparts a crepitant feeling to the fingers when compressed, and on auscultation a loud vesicular murmur is heard. As a rule, no treatment is advisable in this condition beyond the application of a pad or truss.

A similar condition, arising as a complication of an open wound, is termed a **Prolapse** of the lung. An attempt should always be made to return the protruded viscus, and to prevent its recurrence by suturing the aperture through which it has escaped. If left unreduced, it is very likely to become gangrenous from strangulation, and should then be removed by the application of a ligature, the wound being subsequently closed.

Empyema, or suppuration within the pleural cavity, occurs most frequently as a sequela of an acute pneumonia, being perhaps preceded by a simple pleurisy, but is also an occasional result of traumatism. It is not unfrequently associated with tuberculous disease of the lung. The whole pleural cavity may be involved, or it may be limited to a portion of it. Thus, a basal empyema is not an uncommon result of intra-abdominal suppuration, whilst inter-lobular collections of pus also occur, and cause sometimes much difficulty in diagnosis. Bacteriological research has demonstrated that in children more than half of the cases are due to the pneumococcus, either alone or less often in conjunction with streptococci, whilst in adults the streptococcus is the commonest organism. A description of the physical signs and symptoms belongs rather to the physician than to the surgeon. It will suffice to mention here that in a total empyema the affected side of the chest does not move on respiration, whilst the intercostal spaces may bulge; on percussion the side is dull, except perhaps immediately below the clavicle, where tympanitic resonance (Skodaic) may be elicited. On auscultation breath-sounds are absent, except in the vertebral groove, where bronchial breathing may be heard. The loss of vocal fremitus is also an important sign. A certain amount of fever and dyspnœa is usually present in cases of empyema; leucocytosis is well marked, and the heart and other viscera may be displaced. Left to itself, an empyema slowly finds its way to the surface, and perhaps most commonly bursts through the fifth or sixth costal interspace in front, though sometimes through the second, owing to the perforating vessels being larger here than elsewhere. An extrathoracic abscess of some size may develop, and the opening in the skin may not correspond to that in the chest wall. A localized empyema gives rise to similar effects, but on a smaller scale. When situated on the left side in close proximity to the pericardium, the movements of the heart may be transmitted through the fluid to the surface, causing a pulsation which can be seen or felt (*pulsating empyema*).

In the early stages the pleura is but little altered in structure, although a certain amount of lymph may be deposited on it; in old-standing chronic cases it becomes very dense and firm, owing to a development of fibro-cicatricial tissue, whilst the surface is converted into a layer of granulation tissue, similar to that found in all chronic abscesses. The lung collapses and retreats backwards towards the spine; at first its alveolar texture remains unaltered, and the early removal of the exudation enables it to re-expand, as a result of the atmospheric pressure. In chronic cases, however, there are two hindrances to this expansion, viz., the density of the thickened visceral pleura, which resists the atmospheric pressure, and the infiltration and sclerosis of the lung tissue itself. Under these circumstances, even when the exudation is entirely removed, the lung may remain collapsed, and Nature then attempts in several ways to remedy the mischief and obliterate the pleural cavity: (*a*) The opposite lung undergoes expansion and hypertrophy, and together with the heart projects over to the opposite side; (*b*) the abdominal viscera and diaphragm are displaced upwards; (*c*) the chest wall falls in, and the spine becomes laterally curved, with its convexity to the sound side; and (*d*) there is an exuberant growth of granulation tissue from the surface of the pleura. In a certain proportion of cases these structural changes suffice to determine a cure, but in others a cavity still remains, lined with thickened pyogenic membrane, and discharging pus or serum, according to whether or not a mixed infection is present. Under these circumstances extensive operative interference is necessary.

The **Diagnosis** of empyema is readily made by attention to the physical signs, and confirmation of such an opinion can be obtained by puncture with a sterilized exploring syringe. A medium-sized needle should always be employed for this purpose, and it is well to insert it along the top of a rib after drawing the skin up or down, so that on removal a valvular puncture results. The character of the organisms contained in the sample of pus thus withdrawn should, if possible, be ascertained, since it has been proved that the **Prognosis** depends much on this point. Thus, an empyema due to the presence of pneumococci, presumably following a pneumonia, usually runs a mild course, and is sometimes cured by aspiration alone; one due to the ordinary pyogenic cocci is more acute, and requires drainage with or without resection of a piece of rib. The presence of tubercle bacilli renders the outlook much more serious, whilst the addition of a mixed infection to any of the above aggravates the process and much impedes a cure. The chronicity or not of the affection is also a most important element, since the later the treatment commences, the denser are the adhesions which bind down the lung, and the less the chance of its re-expansion. The character of the pus varies with the organisms present; with pneumococci, the pus is usually yellow, creamy, and laudable, whilst there is often an abundant production of fibrinous false-membranes; when of streptococcal origin, the pus is generally thin and oily.

Treatment therefore should never be delayed; the earlier it is undertaken, the better the results.

Aspiration may be adopted in the first instance, but is rather to be regarded as of an exploratory nature, though a cure will occasionally follow when the empyema is of pneumonic origin. It is, however, sometimes of value in very extensive effusions with displacement of the heart, so as to allow the latter organ more gradually to return to its proper position; by this means, too, it becomes possible to administer a general anæsthetic for the more serious subsequent operation. In double empyema (usually seen in children) aspiration also is desirable as a preliminary measure so as to relieve the urgent symptoms. Both sides are aspirated in the first instance, and then one side is opened and drained first, and after a few days the other is similarly treated.

Drainage of the pleural cavity through an external incision is the treatment almost invariably necessary, and as a matter of mechanical convenience it is usually advisable to resect a portion of a rib in order that the drainage-tube may not suffer compression; especially is this the case in children. The best site for opening a complete empyema has been much discussed, and it is probable that subsequent drainage is facilitated by making the opening well back—*e.g.*, in the ninth space just external to the scapular line. Possibly in children with a pneumococcal empyema, which is not likely to need lengthy drainage, a more convenient site may be selected in the fifth or sixth interspace, just behind the mid-axillary line; apart from these cases, an opening here is usually ineffective, and will require a subsequent counter-opening further back. An incision is made along the course of a rib about 1½ inches in length, and the periosteum stripped up from both the superficial and deep aspects of the bone, so as to enable a curved raspatory to be passed beneath it; at least 1 inch of the rib is then cut away with bone pliers. The parietal pleura is opened sufficiently to enable the finger to be introduced and the cavity explored, as also to allow of the removal of flaky masses of fibrin. A large drainage-tube is inserted, just long enough to enter the pleural cavity, but not to project into it; the tube is carefully stitched in, and the wound immediately covered, so as to prevent as far as possible the entrance of unfiltered air. Care must be taken both at the operation and at the subsequent dressings, to prevent the tube being sucked into the thorax, a well-known but easily preventable accident.

Irrigation of the chest is unnecessary and occasionally dangerous; several cases of sudden death have followed this practice, probably due to reflex irritation of the vagus. In chronic cases, however, where a mixed infection is present, irrigation is often beneficial, but the following points must be attended to: (i.) The fluid employed must be sterile and unirritating; (ii.) it must be at the temperature of the body, neither too hot nor too cold; (iii.) it must not be injected with such force as to impinge against the pleura or against the upper surface of the diaphragm; and (iv.) free exit must be given to it, so as to prevent tension from accumulation within the pleural cavity.

If such treatment is undertaken early, the lung may be expected to expand quickly, the discharge steadily diminishing, and the wound healing without delay; but this does not always occur, and then a fistula persists, leading into a cavity lined with a thick pyogenic membrane, discharging a variable amount of pus. The best means of obtaining a cure in these cases consists in removal of the rigid external wall, as by *Estlander's operation*, which is characterized by the excision of portions of ribs comprising the outer wall of the cavity. It is usually carried out through a vertical incision in the axillary line, the ribs being freed from their periosteal connections; the amount excised necessarily varies according to circumstances, and is in some cases very extensive. The fistulous track is enlarged, and the interior of the pleura carefully curetted and washed out, so as to remove all necrotic and degenerating tissue; the parietes are then allowed to fall back into contact, if possible, with the deeper layer, a drainage-tube is inserted, and the side firmly bandaged. A modification of this proceeding is known as *Schede's operation*, in which not only are the ribs removed, but also the intervening tissues, so that the subcutaneous or muscular structures in the flaps are laid down upon the prepared surface of the deeper layer of the pleura.

Necessarily, either of these methods of treatment is associated with considerable deformity, and also with a terrible weakening of the side, and plans have been suggested to obviate this by removing portions of a number of ribs before and behind, so as to leave the intervening segment free to collapse, without totally destroying the osseous thoracic boundary. Another proceeding that has been recently practised with occasional success is the stripping of the thickened pleura away from the collapsed lung, so as to enable it to expand once more (pulmonary decortication). Obviously such a procedure could only be of value when the compression of the lung has not been followed by sclerosis; whilst infection of the pulmonary tissue has resulted in grave inflammatory disturbance and even death. It is more than doubtful whether this proceeding is ever justifiable.

Considerable assistance in gaining re-expansion of a collapsed lung may be obtained by making the patient undertake forced expiratory efforts against resistance—*e.g.*, by learning to play some wind instrument.

Intrathoracic Surgery has been much hindered in its progress owing to the frequent development of pneumothorax, which follows opening the pleural cavity. The teaching of physiologists would lead us to anticipate this catastrophe in every case of pleural puncture; that it does not occur so frequently is due to the power of cohesion of the two moist smooth surfaces of the parietal and pulmonary pleura; over this atmospheric pressure has little effect. In spite of this a large opening into the pleural cavity, especially if conjoined with digital exploration of the lung, will almost certainly result in a pneumothorax which may injuriously or even fatally affect the patient. To avoid this catastrophe, all that is needed is to arrange that the intra-alveolar pressure shall be slightly greater than the intra-pleural pressure when the chest is open, and this desideratum may be obtained in one of two ways:

1. By means of *Sauerbruch's Chamber*. This is an air-tight cabinet in which the surgeon and his assistant are placed for the operation together with the patient's trunk; the patient's head projects through an air-tight window, the neck being surrounded by an india-rubber collar. The chamber is suitably lighted, and all requirements for the operation are previously placed in it. The doors and windows are carefully closed, and by a suitable suction-pump the air pressure in the chamber is reduced to such an extent as not to trouble the operators, and yet to exercise a negative pressure on the exposed pulmonary tissue, and thereby to prevent its collapse.

2. By raising the pressure in the pulmonary alveoli by *intra-tracheal insufflation* (p. 1350). This is easily and readily accomplished by any of the modern contrivances for the administration of ether vapour by this route—*e.g.*, the Elsberg apparatus; the increase of

pressure required does not exceed that represented by 10 or 12 millimetres of mercury. This latter method is far the simpler, and seems to be equally effective.

Pneumotomy, or incision of the lung, has been undertaken for not a few pulmonary lesions, and the results obtained have been rather variable. 1. For *tuberculous cavities* it is of little use. They are usually situated at the apex of the lung and drain well; the original disease is not removed; and the general health is frequently so impaired that the shock of the operation hastens the inevitably fatal issue. Hence it is only required for a cavity located in the lower half of the lung, which drains badly, and the difficulty of diagnosing such a condition is considerable. 2. For *bronchiectases* pneumotomy, though *prima facie* desirable, has given but little benefit, since it is uncommon for only one dilatation of the bronchus to exist. In suitable cases, however, where there is a good deal of fœtid secretion, which is with difficulty expelled, it may be useful. 3. *Gangrene* of the lung and *pulmonary abscess* usually follows acute septic pneumonia in debilitated individuals. The expectoration is abundant and extremely offensive. The localization is made partly with the stethoscope, but mainly with the exploring needle. The gangrenous area is often near the base of the lung. Operation is frequently successful. Of course, the pulmonary abscesses of pyæmia, being multiple, are not suited to operative treatment. 4. In *hydatid* disease of the lung, incision and drainage have so considerably reduced the mortality that this method of treatment should alone be adopted.

As to the *technique* of the operation, the first thing is to locate the mischief, and this is effected partly by a careful attention to the physical signs, partly by the use of an exploring needle or syringe. An incision is then made, and a portion of one or more ribs removed. If the lung is adherent to the thoracic walls, and shows no sign of retracting, the operation may be continued; but if no adhesions are present, and positive intratracheal pressure is not inavailable, it may be well to pack the wound with gauze for a day or two, so as to determine their formation and thus shut off the pleural cavity. It may, however, be possible to stitch the pulmonary to the parietal pleura, and thus prevent collapse. The lung itself may be punctured with sinus forceps introduced along an exploring needle, and then opened, or may be incised with a cautery. The abscess or other cavity is thus emptied of its secretion, and a drainage-tube inserted. As a general rule it is unwise to scrape or irrigate it, for fear of a communication existing with any of the larger bronchi.

Pneumectomy, or excision of a portion of the lung, has been attempted in a few cases of tuberculous disease limited to the apex; the operation is, however, quite unjustifiable, since, if the affection is localized to the apex, it can often be cured by hygienic measures, whilst if it is more diffuse it cannot be extirpated. Primary malignant tumours of the lung, moreover, are usually central, and the diagnosis can rarely be made early enough to warrant an attempt at removal. The only conditions under which it is justifiable to excise portions of lungs are: (*a*) when a hernial protrusion has become strangled through a small opening, and cannot be reduced; and (*b*) when malignant disease of a rib has invaded the superficial portion. In the former case, the base of the protrusion is transfixed and ligatured prior to being cut away; in the latter the disease is snipped away with scissors, and bleeding stayed by cautery, ligature, or plugging.

The creation of an **Artificial Pneumothorax** has occasionally been employed in the treatment of phthisis. Nitrogen is employed for the purpose, and must be washed and filtered before admission to the pleural sac. It is doubtful whether the procedure has any real therapeutic value.

Wounds of the Heart.

Wounds of the Heart and great vessels are so generally fatal, either immediately or within a few hours, that it is unnecessary to discuss them in any great detail. They may be divided into two classes, the non-penetrating and the penetrating. The former are due to crushes of the chest wall, and fragments of the overlying bones may be driven into the heart substance; it is unusual for any surgical treatment to be practicable in such cases. Penetrating wounds (90 per cent. of the whole) have of late years been brought within the range of surgical art, and a number of successful cases of cardiac suture have been reported. The right ventricle is most often injured; the left auricle least frequently. Wounds of the auricles are more dangerous than those of the ventricles, as the thicker and more muscular walls of the latter may suffice to check the bleeding. The outlook depends largely on the nature of the wound, those due to small penetrating bodies, such as stilettos, etc., being the most favourable. The patient may die from immediate cessation of the heart's action; or from intra-pericardial pressure of blood; or from hæmorrhage, internal or external, according to whether or not the blood can escape. If the patient does not die at once, he suffers from intense shock and prostration, combined with a weak and turbulent action of the heart, great pain in the chest, and dyspnœa, whilst the pulse is scarcely to be felt. Purulent pericarditis is likely to ensue. *Treatment.*—The patient must be kept absolutely quiet and with the head low until it is decided whether or not operative interference is justifiable. If the case is to be left, the external wound is purified, but no attempt made to explore it with finger or probe for fear of dislodging clots. If operation is attempted, an anæsthetic is carefully administered so as to avoid struggling, and a suitable incision made in the chest wall; possibly the best plan is to turn up a trap-door flap consisting of parts of the fourth and fifth ribs or their cartilages. The pericardium is freely opened, and the cardiac wound gently explored. It has been found possible to stay a sudden gush of blood by introducing one or more fingers into the ventricle. Deep sutures are then inserted through the muscular substance, for choice during the diastole, and tied; branches of the coronary artery may require ligature. It must not be forgotten that cases have been reported in which a wound of the heart has healed spontaneously, and the patient survived for years.

Effusion into the Pericardium, whether serous or purulent, may require surgical treatment in order to relieve symptoms of cardiac failure, due to the pressure of the exudate. The sac when distended pushes aside the pleuræ and lungs, and also is enlarged upwards, carrying up the base of the heart and rotating the apex forwards to a slight degree. The bare interpleural area of the pericardium is therefore increased, and the cavity may be tapped by trocar and cannula, or by aspirator either close to the left border of the sternum in the fifth interspace, or 1½ inches from the left margin of that bone through the fourth or fifth interspace, so as to avoid the internal mammary trunk, which courses down about half an inch from the border. It may also be reached with safety from the right side of the sternum in certain cases.

For suppurative pericarditis incision and drainage are necessary. This may be readily accomplished by removing the fourth or fifth costal cartilage, thereby exposing the pericardium, which is opened, washed out, and a drainage-tube inserted. Care must be taken to prevent infection of the mediastinal tissues, and this can sometimes be accomplished by stitching the pericardium to the parietes before opening it. Possibly better drainage is provided by operating through the costo-sternal angle (Allingham). An incision is made through the left rectus abdominis, reaching up between the xiphoid and the seventh costal cartilages, the latter being, if necessary, removed. The peritoneum is depressed; the interval between the sternal and costal attachments of the diaphragm is opened up; and the lowest part of the pericardium is thereby exposed, and can be easily drained. The patient is propped up in bed.

Cardiolysis is an operation for the removal of a portion of the chest wall, lying in front of the heart, with the object of replacing the comparatively unyielding thoracic wall by a soft, pliable covering. It has been performed in cases of adherent mediastino-pericarditis to relieve the fixation of the heart to the chest wall, with its consequent mechanical disadvantage; and also for cases of valvular disease with great hypertrophy.

The parts usually removed have been the third, fourth, and fifth left costal cartilages, with or without a piece of the sternum, and the ends of the corresponding ribs. It is desirable to remove the perichondrium, but in cases of adhesive inflammation this may be almost impossible without wounding the underlying structures.

Asphyxia.

Asphyxia, or Apnœa, is the term applied to indicate the condition arising from interference with or stoppage of the respiratory act. If this has not proceeded to any great extent it is termed **Dyspnœa;** when, however, the obstruction is so marked that the patient is obliged to maintain the upright sitting position, the term **Orthopnœa** is applied to it.

The **Causes** of asphyxia may be classified as follows:

1. Conditions arising from the presence of abnormal contents within the air-passages—*e.g.*, foreign bodies; blood-clot or pus from the bursting of an aneurism or abscess; serum, as in œdema of the lung; mucus or muco-pus, as in bronchitis; the consolidated exudation in pneumonia; diphtheritic membrane; or irrespirable gases—*e.g.*, nitrogen, hydrogen, carbonic acid gas, etc., as in suffocation. Death by drowning usually arises from a similar cause, viz., the replacement of air by water in the respiratory passages.

2. Causes arising in the walls of the air-passages, such as diminution of their lumen from inflammatory congestion, as in œdema of the glottis; cicatricial stenosis; the presence of new growths, or the displacement of parts, as in cut throat; or the falling back of the root of the tongue after partial excision of that organ.

3. Extrinsic causes, or those arising outside the air-passages—*e.g.*, in the *neck* ; strangling, hanging, garrotting, etc.; the presence of tumours, such as goitres or aneurisms; a retropharyngeal abscess or tumour; and, under exceptional circumstances, displacement backwards of the sternal end of the clavicle. Within the *thorax* gradually increasing obstruction to the respiration may be caused by the presence of tumours, aneurisms, or effusion into the pericardium or pleura.

4. Nervous causes—*e.g.*, paralysis or spasm of the larynx, and paralysis of the diaphragm, either from peripheral lesions, such as the pressure of aneurisms, or tumours on the nerve trunks, or from central causes, such as a lesion in the upper part of the spinal cord or medulla. It may also arise from paralysis of the respiratory centre, as from an overdose of chloroform.

5. In many forms of cardiac disease the lungs may become engorged with stagnant blood, leading gradually to dyspnœa, orthopnœa, and finally asphyxia, owing to the increasing difficulty in eliminating the excessive accumulation of carbonic acid.

The **Treatment** of the different conditions giving rise to asphyxia cannot here be dealt with *in extenso*, but merely the general plan of treatment indicated. A rapid examination is at once made, to ascertain, if possible, the cause of the mischief, and whether its onset has been gradual or sudden. If it has been gradually developing, it is not uncommonly due to some thoracic condition which cannot be relieved; if, however, its onset has been sudden, and not the result of any evident lesion, the neck and chest should be bared, and examined for signs of traumatism, the mouth opened, the tongue drawn forwards, and the glottis examined with the finger to see that the passages are clear. The patient should, if necessary, be removed into fresh air, and artificial respiration at once commenced. Breathing can sometimes be excited by alternately dashing hot and cold water over the thorax, whilst electric stimulation of the phrenic nerve may also be undertaken, one electrode being placed over the neck and the other on the epigastrium. The administration of oxygen instead of air is useful during the earlier stages, whilst if the condition is due to cardiac disease with distension of the right side of the heart, venesection holds out the best hope of relief. Obstruction within the larynx needs tracheotomy or intubation, as also other conditions associated with pressure on the trachea.

Artificial Respiration is required in a variety of surgical conditions, and can be undertaken by what is known as Sylvester's method. In this the patient lies on his back, with a pillow beneath the shoulders, the mouth opened, and the tongue drawn forwards. The arms are then grasped just above the elbows and drawn upwards above the patient's head, so as to expand the chest through the action of the great pectoral muscles. This position is maintained for about two seconds, and then the arms are lowered to the side, and pressed firmly against the ribs, so as to determine a forcible expiratory act. At the end of about two seconds more the arms are again elevated, and the same cycle passed through. This should be repeated about fifteen times a minute, and the operator must be careful not to use too great violence, or to hurry over it unnecessarily, as harm rather than good thereby results.

Another less satisfactory method consists in alternately compressing the lower part of the thorax and abdomen with the hands, so as to drive out a certain amount of air, and then by suddenly relieving the pressure the elastic expansion of the chest walls draws in a fresh supply.

In the **Treatment of the Apparently Drowned** the air-passages must be cleared as quickly as possible. During the struggles of the drowning man water enters the trachea and is churned up with mucus, saliva, and perhaps blood into a froth which does not easily escape, but must be slowly squeezed out by the application of pressure to the back, whilst the patient is lying face down. At the same time artificial respiration must be maintained, and it is obvious that Sylvester's method is not an ideal plan under these circumstances. The late Dr. R. L. Bowles elaborated a procedure for these cases which admirably suits their requirements, and we have much pleasure in quoting his instructions *verbatim*, and introducing the illustrations which he kindly placed at our disposal:

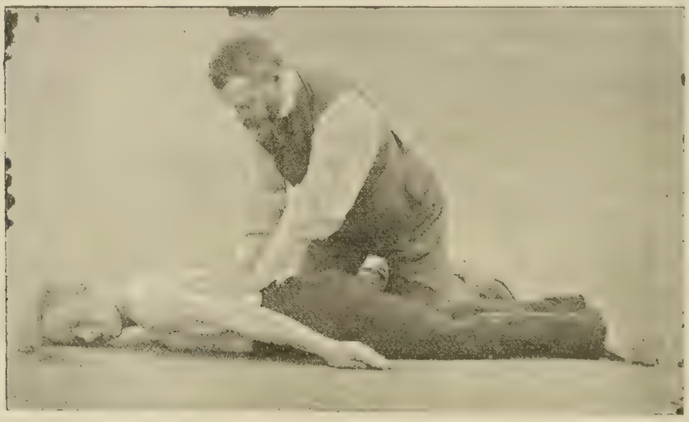


FIG. 441.—TREATMENT OF THE APPARENTLY DROWNED—MOVEMENT NO. 1

'Treat the patient at once and on the spot. Undo any tight clothing. Kneel and place the patient on the right side and quickly wipe out the mouth and throat.

'If there are no signs of breathing, spread a handkerchief on the ground where the patient's mouth will come, and carry out

'*Movement No.* 1.—Turn the patient flat on the stomach, and at once with widespread hands press gently but firmly for three or four seconds on the back of the ribs on both sides to squeeze out the froth, fluid, or foul air (Fig. 441). Then suddenly remove the hands to allow the entrance of air by the natural recoil of the ribs, and proceed to

'*Movement No.* 2.—With the right hand grasp the patient's left shoulder; with the left hand take his left wrist, place it against his hip, and roll him towards you on to his right side (Fig. 442). This movement should take about two seconds

'Repeat first and second movements in succession for ten minutes

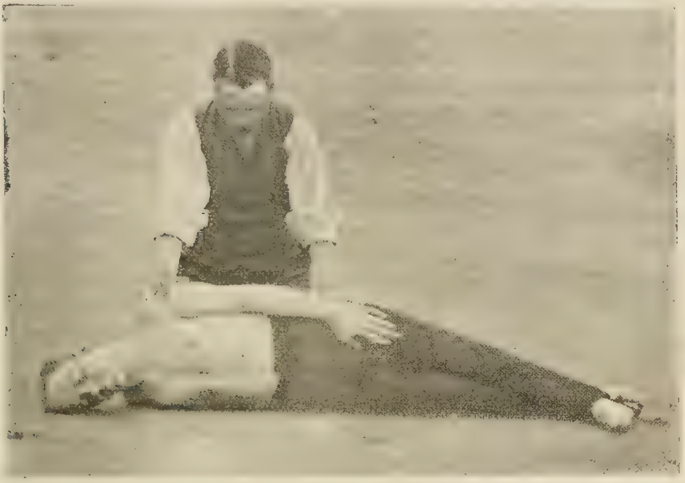


FIG. 442.—TREATMENT OF THE APPARENTLY DROWNED—MOVEMENT NO. 2.

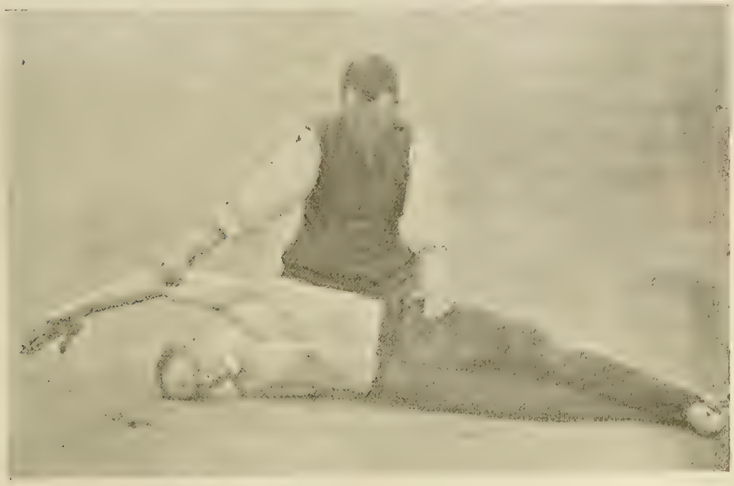


FIG. 443.—TREATMENT OF THE APPARENTLY DROWNED—MOVEMENT NO. 3.

or more (if necessary), when some of the froth or fluid will have drained away from the lungs, and then proceed to

'*Movement No.* 3.—Each time the patient is rolled from the stomach on to the right side, take hold of the left or uppermost arm and raise it above the head in a line with the body. This movement expands the chest still more and allows air to enter the upper left lung (Fig. 443). Then bring the arm down to the side, roll the patient on to the stomach, and begin again at movement No. 1, and continue each movement in succession as before, for an hour or until signs of natural breathing begin.

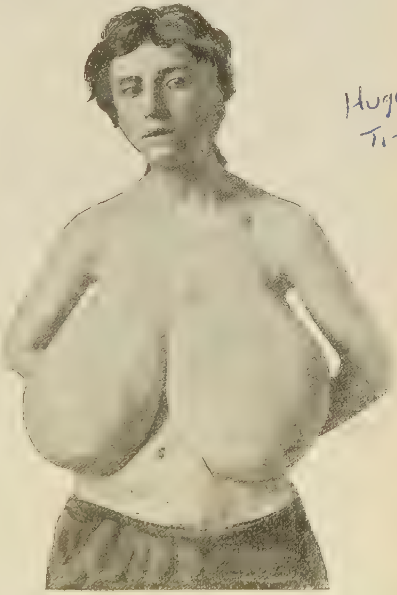
'Always turn the patient on to the right side, never on the left, and under no circumstances on the back. From time to time wipe away froth from the mouth and nose.

'The neck should be kept fairly straight and the chin away from the breast-bone; the head may then be left to take care of itself, and the face will take no harm, as it will remain chiefly on its side, and yet perfect drainage will be ensured.'

CHAPTER XXXIV.

DISEASES OF THE BREAST.

Congenital Malformations of the breast are much more common than is generally supposed. One or more accessory breasts (*polymastia*) or nipples are found either below the normal one or just above it; sometimes they have been found in the axilla, on the outer side of the thigh, or other unusual situations. They are often of a most rudimentary nature, but in a few cases have secreted milk. Very rarely the breasts are entirely absent (*amazia*). Occasionally the male breast becomes enlarged to the ordinary size of a virgin's breast (*gynecomastia*); the organ is usually functionless, since the overgrowth mainly affects the stroma, although lactation has been known to occur. The condition may be associated with imperfect or irregular development of the sexual organs.



Huge
Tits

FIG. 444.—DIFFUSE HYPERTROPHY OF THE BREASTS.

It occurred in a girl aged sixteen and a half years, and both organs had to be removed. The left breast weighed 9½ lbs., the right breast 9 lbs.

Diffuse Hypertrophy of the breast (Fig. 444) consists of a general enlargement of the organ, both gland substance and interstitial tissue participating in the process, and hence the breast becomes firm and indurated. It may be uni- or bi-lateral, perhaps more frequently the latter, and generally occurs in adolescents. The size varies considerably, but the breasts may become enormous, hanging down by their weight, and perhaps to such an extent as to rest on the knees of the patient when sitting.

They are usually painless, although sometimes neuralgia is noticed. Functionally they are useless, as even if the patient becomes pregnant, secretion of milk but rarely occurs. No cause can be assigned for the overgrowth, and the only treatment is amputation, when the increased size is causing discomfort.

Affections of the Nipple.

Fissures of the Nipple (cracked nipples) seldom occur apart from lactation, and may usually be traced to a want of care and cleanliness on the part of the mother, associated with a tender condition of the skin, which might have been prevented by bathing the parts during the later weeks of pregnancy with spirit, so as to harden them. The actual lesion is brought about by leaving the nipples wet after nursing. The superficial layers of epithelium become macerated, and are easily rubbed off, thus exposing the more delicate and sensitive deeper parts, which are irritated and inflamed by the repeated acts of suction. As a result, nursing becomes painful, and if persisted in, the wound may be infected, the inflammation spreading to the breast substance along the ducts or lymphatics, or extending along the superficial lymphatics to the axillary glands.

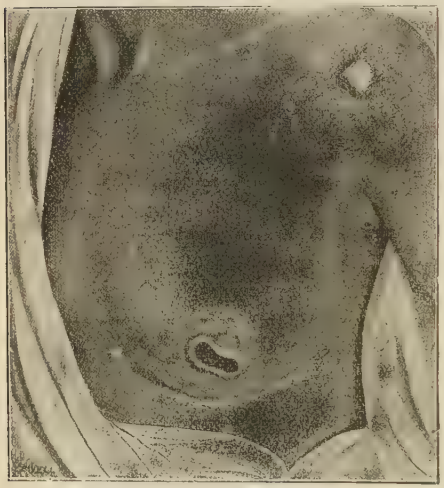


Fig. 445.—Chancre of the Nipple. (From Photograph and Sketch lent by Professor Rushton Parker, of Liverpool.

Treatment.— The best way to prevent the occurrence of cracks is to bathe the nipples with some dilute antiseptic, such as boric acid lotion, immediately after nursing, and then to dry them thoroughly. If at all tender, a little powdered boric acid and starch may be dusted over them in the intervals. When a fissure has formed, it should be dressed with cooling or antiseptic lotions—*e.g.*, lotio plumbi or lotio acidi borici. Sometimes more stimulating applications are required, such as a solution of sulphate of copper, or even of nitrate of silver. It is also recommended to paint the sore with equal parts of glycerine and sulphurous acid.

Eczema of the Nipple may be of a simple nature, needing nothing but ordinary treatment, or it may take on special features, being then known as **Paget's Disease** (*dermatitis maligna*), a condition really due to a carcinomatous development in the skin. It is seen, but very rarely, in parts other than the breast. It presents a smooth, red, raw surface, discharging a yellowish viscid fluid, and may occasionally spread widely beyond the areola. The progress is very slow, but the condition is almost invariably followed by a cancerous tumour in the breast, which may resemble either a duct cancer or an ordinary scirrhus. No local treatment is of any avail, and the disease, when once recognised with certainty, is best treated by removal of the breast and axillary glands.

Abscess of the Areola is not uncommon in young girls about the age of puberty, arising in the sebaceous follicles, and requiring no special notice.

Chancre of the Nipple (Fig. 445) is rarely seen in the mothers of syphilitic children (Colles's law, p. 171), but much more commonly in wet-nurses. It usually presents as a shallow ulcerated surface with a well-marked, raised, and indurated border. Not uncommonly the condition is symmetrical.

Primary Tumours of the Nipple are met with, such as papilloma, sebaceous cysts, and occasionally epithelioma.

Inflammatory Affections of the Breast.

Acute Mastitis is most often observed in *puerperal* women, owing to the sudden establishment of function in the breast after the birth of a child, and to its maintained activity during lactation. It usually results from a sore or cracked nipple, through which pyogenic organisms find their way into the lymphatics or acini of the breast substance. In the former case the inflammation is mainly interstitial in character, the pus diffusing itself widely between the lobules; in the latter the pus is primarily intra-alveolar. Simple obstruction to one or more of the ducts from inflammation of the nipple, without any external wound, also determines an attack of mastitis, which is frequently non-suppurative in character. In *non-puerperal* women acute mastitis may result from injury, or may be pyæmic in origin. Occasionally a metastatic inflammation of the breast occurs after the disappearance of the parotid swelling in mumps; whilst in girls about the age of puberty a subacute inflammation, involving both the breast and areola, and even terminating in suppuration, has been observed. In newly-born infants a similar inflammation, sometimes running on to suppuration, has been seen, possibly resulting from an infection of the gland ducts during birth with cocci from the maternal passages. A slight enlargement, with congestion of the breasts, often occurs after birth, and may be aggravated by the foolish habit followed by ignorant midwives of pulling or forcibly squeezing them in order 'to break the nipple-strings.'

Signs and Symptoms.—An inflamed breast is characterized by the organ becoming swollen, acutely painful, and tender. The gland lobules are felt to be enlarged and indurated, whilst if lactation is progressing, the secretion is to some extent impaired; but owing to the inability of the mother to allow the child to relieve the organ, on account of the pain produced thereby, considerable tension results from accumulation of milk. If suppuration follows, the skin over the breast becomes red and œdematous, and, according to the situation of the pus, three different forms of acute abscess of the breast are described: (*a*) *Supramammary abscess* is the term applied to a collection of pus in the subcutaneous tissues or beneath the nipple; it is often unconnected with the organ, or may originate in the superficial lobules. It does not burrow deeply, and comes readily to the surface. (*b*) An *intramammary abscess* is the most common variety, the pus developing within, and distending the lobules, or infiltrating the cellular tissue around them; it is usually diffused widely throughout the organ, and may point at several spots. When very acute, or in debilitated women, especially if it has been allowed to progress without treatment, the inflammatory process may actually determine gangrene of the glandular tissue. (*c*) A *submammary abscess* forms in the cellular tissue beneath the breast. It may spread from the deep lobules, but more frequently results from disease of some of the adjacent ribs or cartilages, or starts as a cellulitis. In these cases the breast is pushed forwards, and becomes prominent, floating, as it were, on a bed of pus. The abscess usually points at the periphery of the organ, perhaps in several places, but most commonly at the lower and outer quadrant.

Inflammation of the breast occurs in women who are anæmic and weakly. Even the simple forms are associated with fever and malaise, and these become exaggerated if suppuration ensues, owing partly to the pain, and partly to the absorption of toxins.

The **Treatment** of simple acute mastitis consists, in the first place, in supporting the inflamed gland by means of a sling or bandage, and in binding the arm to the side, so as to keep at rest the pectoral muscle, on which it lies. Fomentations are then applied, and any tension due to retained secretion is relieved by the breast-pump. The bowels are opened, and the patient placed on a light and nourishing diet, whilst stimulants and tonics, such as iron and quinine, may be judiciously administered.

As soon as the acute stage has passed, friction with warm oil, or the inunction of a belladonna ointment, is advisable.

When suppuration is threatening, the breast may be poulticed until fluctuation is detected; but under no circumstances must the abscess be allowed to burst into the poultice, and thus become septic. If such a practice is permitted, chronic suppuration ensues, and the breast may become riddled with sinuses. The most rigid asepsis must be maintained in these cases, and as soon as pus is evidently present, an incision should be made to permit of its escape. In the *supramammary* variety it matters little in which direction the cut is made, since the pus is always superficial to the breast tissue. In the true *intramammary abscess* the incisions should radiate from the nipple. One or more may be needed, and these should be made with a free hand, so as to allow of the insertion of the finger, and the opening up of any pockets or lobules which are distended with matter. A large drainage-tube is inserted for a time, and gradually shortened day by day, until its entire removal is permissible. When the chief incisions are needed above the nipple, it is often wise to make a counter-opening in the lower half of the breast, and generally on the outer side, to permit of more efficient drainage. With such treatment the best of results may be attained, and it is interesting to note how quickly the contour of the breast is restored, and how slight is the permanent injury inflicted on the parts. The *submammary abscess* is best opened towards the lower and outer side, but also at any spot where pus points.

If discharging sinuses persist after an abscess has burst, their orifices should be enlarged, and their walls thoroughly scraped and disinfected; deep cavities should be efficiently drained and packed with gauze, so as to ensure the wounds healing by granulation; the arm must also be kept to the side.

Chronic Mastitis occurs in two forms—one, a localized affection of one segment of the breast (chronic lobar mastitis), the other involving the smaller lobules and interstitial tissue (chronic lobular or interstitial mastitis).

1. **Chronic Lobar Mastitis** is by no means unfrequent as a result of imperfect involution of the organ at the cessation of lactation, but may arise from blows or squeezes, and especially in young women; it may also follow a subacute or acute attack, which has not ended in suppuration. It is characterized by an enlargement of one or more lobes of the organ, which are usually tender, and often excessively painful, the pain being of a neuralgic character, and increased during menstruation. The condition is of comparatively little importance, but may give rise to a great deal of anxiety and worry. All that is necessary in the shape of **Treatment** is to support the part and keep the arm at rest in a sling, whilst an ointment containing belladonna, or a belladonna plaster, may be applied.

2. **Chronic Lobular or Interstitial Mastitis** is an affection which occurs not unfrequently in women with small or atrophic breasts, who have passed, or are near to, the climacteric. It is also met with at an earlier age in unmarried women, involving the whole of one or both breasts, or limited in its development to a portion of one breast, and then being sometimes mistaken for a malignant tumour. **Pathologically,** it is characterized by diffuse overgrowth of the connective tissue, which becomes thickened and perhaps sclerosed, This is associated with well-marked epithelial proliferation, so that sometimes in the earlier stages the acini are filled with a thick cheesy or grumous material which can be squeezed out in thread-like masses, often of a dirty brown or greenish-yellow colour. Cysts are formed in the gland tissue, partly by liquefaction of this proliferated epithelium, partly by exudation into the acini of serous fluid, which is unable to find an exit owing to the pressure of the interstitial growth. Such are known as ‘ involution cysts,’ and the

fluid contained therein is usually clear and limpid; but may be brown and turbid, from admixture of blood; intracystic growths are not present. As a rule, many of these cysts are scattered widely through the breast substance, but they are small and insignificant; occasionally one or more of them become notably enlarged, and simulate a tumour, especially when covered in by a mass of thickened glandular tissue.

Clinical History.—The condition often passes unnoticed in the early stages, until a distinct lump has formed, which is nodular and indurated to the touch, and often very painful. The breast may be somewhat enlarged, and there is, perhaps, some retraction of the nipple, owing to contraction of the interstitial tissue; but this is by no means an essential feature. A scanty serous discharge from the nipple is sometimes noticed. The skin seldom becomes adherent to the swelling, whilst the lymphatic glands in the axilla may be enlarged and tender, but they are never hard. On careful examination of the breast, the affection is rarely found to be limited to one particular region, for although a distinct enlargement of one portion may be present, yet the whole organ feels more or less 'lumpy,' and not unfrequently the other breast participates in the same change. Small, rounded, elastic spots can often be detected, and indicate the presence of cysts. There may be but little pain, although this is sometimes one of the most marked features of the case; it is of a neuralgic type, and usually increased at the menstrual periods.

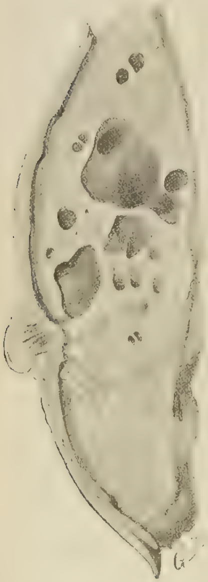


FIG. 446. — GENERAL CYSTIC DISEASE OF THE BREAST, RESULTING FROM CHRONIC INTERSTITIAL MASTITIS.

In this case both breasts were equally affected, and were removed at the same time.

If left to run its course, the disease may remain much in the same condition for many years, and even in time disappears; but more frequently it slowly progresses, and then results in one of three conditions: (*a*) *General atrophy*, the breast becoming shrunken, hard, and nodular. (*b*) More frequently *general cystic disease* (Fig. 446) follows, a condition in which the organ becomes transformed into a number of cysts held together by dense connective tissue. (*c*) There is some question as to whether or not *cancer* is a sequela of this disease; there is abundant evidence to prove that any continued source of irritation in an organ like the breast renders an individual with a cancerous inheritance more liable to its development, especially if it commences at or about the climacteric.

The **Diagnosis** is sometimes easy, but the condition often simulates somewhat closely a scirrhous tumour. The chief points of distinction, however, lie in the facts (i.) that the whole breast is more or less involved; (ii.) that the opposite organ is very often similarly affected; (iii.) that enlargement of the axillary glands is less common than in scirrhus, and even if enlarged they are not hard, as in the latter disease; (iv.) that the skin is usually free from the mass; (v.) that the tumour is never adherent to the pectoral fascia, nor is it of the stony hardness of a scirrhus; and (vi.) that it is often more disseminated and less defined than a cancerous growth. (vii.) Moreover, on careful palpation with the flat of the hand, it is often impossible to make out any distinct lump, the so-called tumour merging into the surrounding tissues; this never occurs in scirrhus, the growth always being easily detected with the flat of the hand. Small cysts can also be felt as localized elastic spots in the inflammatory mass. Of course it is possible for the two conditions to co-exist, and in doubtful cases an exploratory incision, and microscopic examination of a portion of the tissue, can alone be depended on.

Treatment.—In the early stages, and especially in the younger patients, friction with some sedative application containing belladonna may be used at the same time that the breast is supported, and freed from the irritation of badly-fitting stays. Firm and equable pressure, as by strapping, is also useful in some cases whilst iodides may be administered. If a definite tumour is present, or if many cysts can be detected, and especially if the patient is anxious and worried about herself, it is wise to remove the affected portion or even better to excise the whole breast, especially when there is a family history of malignant disease.

Localized or Encysted Chronic Abscess is usually associated with pregnancy, and is characterized by the formation of an indurated mass in the breast substance, which slowly softens, giving rise to a sense of fluctuation, although when the abscess walls are very thick, as is often the case, it may be exceedingly difficult to detect this. Retraction of the nipple is not uncommonly present, and the axillary glands may be enlarged. The condition has frequently been mistaken for a tumour, but is recognised from it by its incorporation with the breast substance, by its lack of definition, and by the fact that on careful examination elasticity can be felt at its centre, which is almost always less resistant than the margin, whereas the opposite is the case with a tumour. In cases of doubt the insertion of a grooved needle or an exploratory incision will settle the diagnosis. Sometimes chronic abscesses of the breast are of a tuberculous nature.

Treatment consists in opening the abscess cavity, scraping out its interior, disinfecting with pure carbolic acid, if tuberculous, and draining or packing it.

Diffuse Tuberculous Disease of the breast is not very uncommon. Scattered nodules of caseous material are developed in the inter-acinous tissue, which break down into pus, and come to the surface at various spots. The breast may thus become riddled with sinuses discharging caseous pus. It may be associated with tuberculous disease of the lungs, whilst a like affection may arise secondarily in the axillary glands; possibly in some cases the primary trouble lies in the glands, the breast being subsequently involved.

Treatment should be carried out, if possible, by incision, scraping, and purification of the cavities; but if the tuberculous foci are multiple, it is wiser to amputate the breast.

Occasionally a *chronic tuberculous submammary abscess* forms as a result of a similar affection of the ribs or costal cartilages. It develops slowly, pushing the breast forwards, and is easily recognised, although the causative lesion can only be ascertained by exploration. It must be opened thoroughly, and its wall scraped and disinfected, whilst attention is also directed towards the affected bone.

Syphilitic Diseases of the Breast.—As already pointed out, a primary sore may be met with on the nipple; secondary mucous tubercles, or condylomata, are found in a similar situation or beneath a pendulous breast, whilst superficial and deep gummata have in rare cases formed in the tertiary period of the disease.

Cysts of the Breast.

When the structure of the breast, its abundance of ducts and alveoli, and its complex lymphatic distribution are considered, it is not surprising that many different forms of cystic change are associated therewith. The following are the more important:

1. **Acinous or Retention Cysts** arise, as the name suggests, from some obstruction to the ducts or lobules, whereby the secretion of the organ is unable to escape. They are met with most frequently in women during or after the puerperal period, a milk cyst, or *galactocele*, being then produced. It usually results from compression of one or more of the ducts, connected with a sore nipple, and contains inspissated milk; it forms a rounded swelling and is located near the nipple. The wall is lined with epithelium and surrounded by a fibro-cicatricial layer, the thickness of which increases with the chronicity of the case. In very old-standing cases the fibrous wall becomes very dense, and may cause retraction of the nipple and puckering of the skin, closely simulating a scirrhus. The condition is treated by excising or draining the cavity.

Similar glandular cysts form, as already described, in the course of chronic interstitial mastitis, and are then known as *involution cysts;* in long-standing cases, general cystic disease of the breast may follow.

Retention cysts have also been described as resulting from irritation of the nipple, as, for instance, when a young, non-pregnant woman constantly puts a baby to her breast; it may also occur apart from such irritation in young and vigorous unmarried women, as an expression of the inherent capacity of the gland for functional development. The organ becomes enlarged, the epithelium proliferates, and a thin serous fluid is secreted, which does not entirely escape, and by its distension of the lobules gives rise to what may be termed *irritation cysts*. They may in time undergo spontaneous absorption, but Erichsen describes a case of this nature in which the swellings did not disappear until the patient subsequently became pregnant. Chronic interstitial mastitis may sometimes supervene.

Again, one frequently finds cystic dilatation of the ducts and lobules arising in connection with certain tumours of the breast, such as duct papilloma, duct cancer, or cysto-adenoma. In the latter cases hæmorrhage from the contained growth is often seen, giving rise to a blood-stained discharge from the nipple. A scirrhous growth also occasionally starts from the wall of an acinous cyst.

In most of these retention cysts, discharge from the nipple occurs on squeezing the organ.

2. **Interacinous Cysts** develop in the interstitial tissue of the breast.

(*a*) **Serous Cysts** originate from a dilatation of lymph spaces. They may be uni- or multi-locular, perhaps more frequently the latter. They are lined by a smooth, shiny layer of endothelium, and contain serum, perhaps blood-stained, and in old-standing cases cholesterine; being separate from the gland substance, they never give rise to a discharge from the nipple, and intracystic growths are unknown. They are usually surrounded by a wall of connective tissue which may become exceedingly thick and dense. Occasionally, however, they project under the skin, and if the walls remain thin, fluctuation, and even translucency, can be observed, leading to the condition sometimes badly termed a *hydrocele of the breast*.

The **Diagnosis** of a serous cyst, if the wall is thick, is often a matter of considerable difficulty, as it resembles in many ways a scirrhus. It is recognised, however, by the facts that the growth is incorporated with the breast substance, usually occurring near its under surface; that on careful examination an elastic resistance is transmitted to the fingers, quite distinct from the stony hardness of a scirrhus; that there is no retraction of the nipple and no enlargement of the axillary glands, whilst, as a rule, the patient complains of but little pain. The diagnosis in cases of doubt may be readily determined by inserting a grooved needle, or by an exploratory incision, which should be made of sufficient depth to ensure the thorough division of the mass, for fear that a small cyst surrounded by walls of fibrous tissue, half an inch, or even an inch, in thickness, should be mistaken for a solid tumour.

Treatment.—Although it may suffice to lay the cavity open and drain it, it is decidedly wiser to remove it completely.

(*b*) **True Hydatid Cysts** are occasionally met with, manifesting the general characteristics described at p. 233.

3. Cysts may also arise in connection with cancerous or sarcomatous tumours, from degeneration of tissue in the former case, and from hæmorrhage into the substance of the latter.

4. **Dermoid Cysts** are described; but it is a little doubtful whether old galactoceles have not been mistaken for them.

Tumours of the Breast.

In investigating any case of tumour of the breast, the surgeon must never arrive at a hasty conclusion, but only give an opinion as to its nature after careful and detailed examination. Thus, the age and previous history of the patient should be considered, as also the family history. Simple tumours generally arise at an earlier date than the malignant, whilst the sarcomata usually affect younger individuals than the carcinomata. There can be little doubt, moreover, as to the occasional tendency of tumours to run in families. The length of time for which the swelling has been observed should be ascertained, and whether or not it varies in size at the menstrual periods. The general appearance of the patient should be noted, as also the fact whether or not pain, local or neuralgic, is experienced. It is not unusual for pain to be referred to that part of the shoulder supplied by the posterior division of the second intercostal nerve, the anterior branch of which goes to the breast. A careful inspection of the organ should then be made, comparing it with the opposite breast, so that any signs of asymmetry may be noted. Dimpling of the skin, projection of the tumour or of the whole gland, and the situation and condition of the nipple, are the chief points to which attention should be directed. Examination of the tumour with the flat of the hand, accompanied by gentle pressure of the finger-tips, must then be undertaken; it is not enough to pick up the breast substance between the fingers, as thereby false impressions are obtained. The relation of the tumour to the gland, its shape, its consistency, whether fluctuating or not, and its mobility on superficial, deep, and surrounding parts, should all be investigated. To this end the breast must also be examined with the arm raised well above the head, so as to put the fibres of the pectoralis major on the stretch; transverse movement of the organ across the fibres is always possible, unless the growth is fixed to the thoracic wall; movement in the direction of the fibres is at once limited if the tumour has invaded the muscle, or even if the overlying fascia is seriously involved. Finally, the lymphatic glands in the axilla must be carefully examined, as also, in suspicious cases, the supraclavicular glands and the opposite breast and armpit.

The chief types of tumour met with in the breast may be arranged in three groups: the adenomata, the sarcomata, and the cancers. A few other conditions have been observed, but are so rare that they need no special description—*e.g.*, lipoma, fibroma, chondroma, and osteoma.

Adenoid Tumours of the Breast.—This group includes the two forms of fibro-adenoma (the hard and the soft) and the cystoadenoma. All are characterized by the existence of spaces lined with epithelium, which does not extend beyond the basement membrane. The spaces may contain a variable quantity of fluid, and in some cases intracystic growths are a prominent feature The interstitial tissue is sometimes of a very embryonic type.

A pure **Adenoma** is said to occur, but is very uncommon. Its texture would be identical with ordinary mammary tissue, and its characters with those of a fibro-adenoma, except that it is a little softer.

The **Hard Fibro-adenoma** (or **Adeno-fibroma**) is the most common mammary tumour met with in young people before the age of thirty; it is often attributed to a blow or squeeze, and doubtless correctly. It occurs as a more or less rounded or oval mass, which, if placed superficially, moves freely in the breast substance, and, indeed, may be described as floating in it (Fig. 447); if situated deeply, it still appears quite moveable, but its definition is less evident. Sometimes several such growths are found in the same breast. A fibro-adenoma is usually firm and more or less elastic in consistency, of slow growth, and it may be either painless, or in anæmic and neurotic women exceedingly painful, the pain often increasing at the menstrual periods. There is no concurrent enlargement of the axillary glands, unless arising from other causes, and no retraction of the nipple, with which it is entirely unconnected; the skin over it does not dimple. The general health is unimpaired unless the patient is suffering from an associated anæmia. On section the tumour is of a grayish-white colour, becoming pink on exposure to the air. It is more or less foliated in texture, being compared by Virchow to the section of a cabbage; no juice can be obtained on scraping the

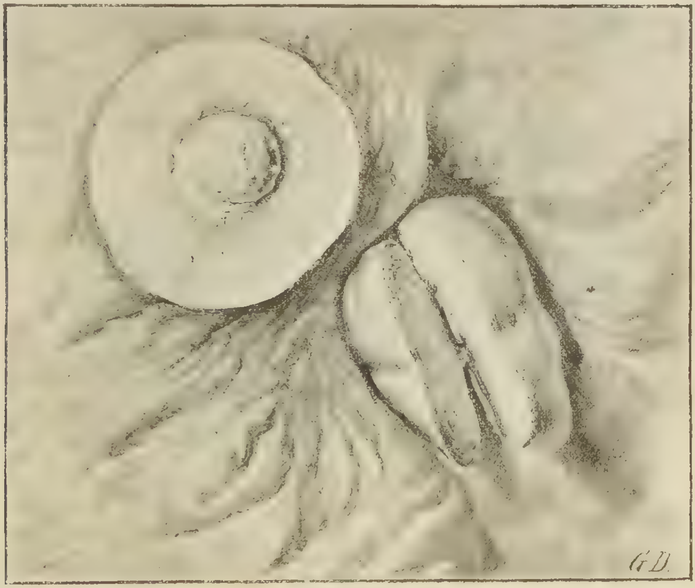


FIG. 447.—FIBRO-ADENOMA MAMMÆ. (FROM MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

cut surface with a scalpel, although on pressure some fluid of a thick glutinous or mucoid nature may escape. Microscopically, the tumour consists of imperfectly developed glandular elements, surrounded by a considerable amount of firm interstitial tissue (Fig. 61), but ducts are never present. The tumour is distinctly encapsuled, except at the one spot, through which vessels enter, and at which it is connected with the neighbouring mammary tissue. It is stated that fibro-adenomata are occasionally converted into sarcomata, thus changing their type from simple to malignant; the evidence, however, as to this is not conclusive.

The **Diagnosis** is readily made if the above signs are considered. An adenoma differs from chronic interstitial mastitis or a serous cyst by its exact definition and free mobility, whilst from malignant tumours it is distinguished by its slow rate of growth, and its freedom from adhesions either to the skin or to surrounding parts.

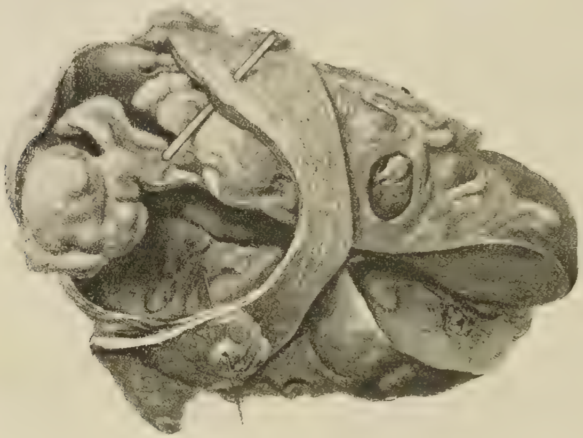


FIG. 448.—CYSTO-ADENOMA MAMMÆ. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

The intra-cystic growths are seen projecting from a large cyst, into which a bristle, passed down the nipple, enters. A glass rod has also been passed into the cyst through a perforation in the skin.

The **Treatment** consists in its removal, which is easily affected by cutting down upon the tumour in a direction radiating from the nipple, until the capsule is reached, when the mass is enucleated from its surroundings with a few touches of the knife. When the growth is situated deeply in the upper half of the breast, a crescentic incision may be made along the lower and outer border of the organ, and by burrowing upwards, the breast can be turned over sufficiently to permit the tumour to be removed from the deep aspect; the scar will be subsequently hidden (Thomas's operation).

The **Soft Fibro-adenoma** differs from the above mainly in the increased rate of growth, in its soft consistency, and in the fact that the interstitial tissue is of a more embryonic character, and, indeed, is often of a mucoid nature; it is sometimes incorrectly termed an adeno-sarcoma. It usually occurs in women at a somewhat earlier period of life than cancer—viz., between the ages of twenty-five and thirty-five. It may consist from the first of a localized tumour, increasing rapidly in size, or it may possibly commence as a hard fibro-adenoma, which, after remaining quiet for a time, takes on a more active development. It remains, however, throughout its course strictly encapsuled, and when large may lead to pressure-atrophy of the true gland substance. It is soft and elastic in consistency, usually painless, and freely moveable on the surrounding breast tissue. The skin over it remains healthy, although distended and atrophic when the tumour is of large size; the nipple shows no sign of retraction; the axillary glands are not involved, and there is no systemic invasion. On removal the section is similar to that of a fibro-adenoma, but cysts are often present, as also areas of mucoid softening, somewhat resembling sago. It can be readily removed in its entirety, and does not tend to recur.

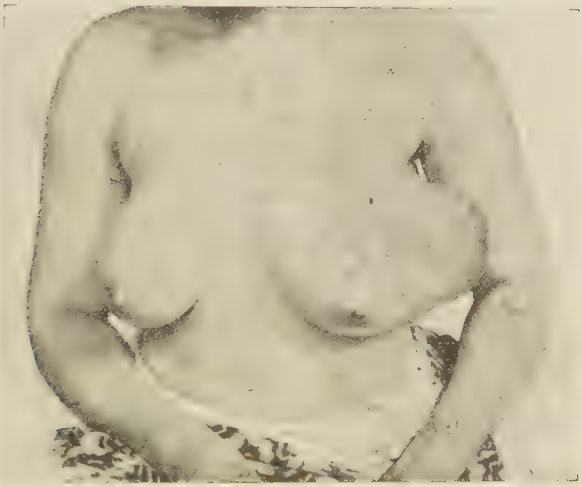


FIG. 449.—CYSTO-ADENOMA MAMMÆ. (FROM A PHOTOGRAPH.)

Cysto-adenoma (*Syn.*: **Cysto-sarcoma, Adenocele, Intracanalicular Adenoma,** etc.) is a condition characterized by a marked development of intracystic growths, consisting of newly-formed fibrous tissue covered with epithelium, within the dilated acini of a newly-formed mass of adenomatous tissue, or within the smaller ducts (Fig. 448). It usually has a definite capsule, and then the normal gland tissue may be pressed aside, and perhaps atrophies. Several cysts are, as a rule, present, and may be of great size, the intracystic growths also varying in amount. Sometimes there is only one large cauliflower-like mass in a cyst; sometimes there are several smaller pedunculated growths. The epithelium covering them is cuboidal or columnar; they are exceedingly vascular, and hæmorrhage into the cavity of the cyst frequently occurs, as also a blood-stained discharge from the nipple. They are due to a proliferation of the interacinous tissue, which pushes the epithelial wall of the duct or acinus before it. The tumour produced is irregular or lobulated in outline, owing to the projection of the cysts (Fig. 449); it is usually painless, and unaccompanied by enlargement of the axillary glands; if of large size, blue veins are seen coursing over it. In the later stages the capsule becomes adherent to the integument, and finally, owing to the pressure of the tumour, the skin may give way, allowing the growth to protrude. This will be followed by the development of a fungating mass, which bleeds readily, and becomes extremely offensive. With care a probe can be passed between the intracystic portion of the growth and the thinned and stretched skin, which has merely given way, and is not incorporated with it; this fact is a ready means of distinguishing this condition from a fungating encephaloid cancer. The tumour is essentially benign in nature: it is never disseminated generally, and can be readily and completely removed, so that there is but little tendency to recur. In the early stages it is unnecessary to take away the entire breast if the tumour can be efficiently dealt with otherwise, but in the later stages the whole organ should be excised.

Somewhat similar in nature to the above is the condition known as a **duct papilloma.** This is characterized by the development of a soft polypoid papillomatous mass, generally of small size, in the interior of one of the terminal galactophorous ducts, which in consequence becomes dilated. A discharge of blood-stained serum results, and there is usually but little tumour to be felt, although the nipple may be slightly pushed forwards and rendered prominent. It is often the precursor of a duct cancer. Amputation of the breast will in many cases be needed, but it may be feasible in some to deal with the tumour alone.

Sarcoma of the Breast is not a common disease (2 to 8 per cent. of all mammary tumours). It originates in the connective tissue of the organ, being deeply placed in its substance, or perhaps more frequently developing in the outer and upper quadrant. It is of two chief types: (*a*) The *round-celled* sarcoma forms a soft, somewhat elastic swelling, which grows rapidly, and although often limited at first by a fibrous membrane, the capsule sooner or later yields, allowing the growth to become diffused through the organ. It sometimes gives rise to secondary growths in the axillary glands, or becomes disseminated throughout the body by means of the blood-vessels. Cysts often occur in its substance, resulting either from hæmorrhage or occasionally from the dilatation of an incorporated glandular alveolus; in the latter case the cavity will be lined with epithelium. Myxomatous changes are also not unfrequently observed, and in the more rapidly growing recurrent tumours the mass is often a true myxo-sarcoma. It usually occurs in women between the ages of thirty and forty—*i.e.*, somewhat earlier than scirrhus—whilst its rapid growth and the absence of retraction of the nipple or dimpling of the skin are useful diagnostic features. Should pregnancy follow, the tumour may increase in size at an alarming rate. In the infiltrating forms it is almost impossible to distinguish it from encephaloid cancer, except on microscopic examination. (*b*) A *spindle-celled* sarcoma, or fibro-sarcoma, is also met with, forming a rounded or oval tumour, more limited than the above, and growing less rapidly. It somewhat simulates an adenoma, but is more closely connected with the breast substance. The axillary glands are but rarely involved, and the sarcomatous nature is recognised by the microscope and by the great tendency of the growth to recur even after apparently complete removal; on account of this latter feature, the name of 'recurrent fibroid tumour' (Paget) was formerly applied to it. The recurrences generally take place at gradually diminishing intervals, and the tumour may then become softer and more vascular; occasionally the tendency to recur seems to wear itself out after the performance of several operations.

The **Treatment** of sarcoma mammæ consists in the removal of the entire organ at as early a date as possible, together with the axillary glands.

Cancer of the Breast.

No organ of the body, with the exception of the uterus, is more frequently the seat of cancer than the female breast; it also occurs in the male subject, but is about a hundred times less common than in the other sex.

Ætiology.—Cancer of the breast is usually met with after the age of forty, although the disease may occur at a much earlier date. It equally affects women who have borne children and nulliparæ, and the question whether or not the woman has nursed her children seems to have but little influence. The left breast is more often affected than the right. It is frequently attributed to some injury, such as a blow or squeeze; whilst there is little doubt that badly-fitting stays are responsible for a certain percentage of the cases. It not uncommonly follows eczema of the nipple, especially that variety known as Paget's eczema; chronic interstitial mastitis may also possibly be an occasional precursor of this affection. The question as to heredity is one exceedingly difficult to decide, and, although it may be a marked feature of some cases, it is somewhat doubtful whether, as a general rule, it has any considerable influence.

Two distinct types of cancer are met with in the breast—viz., the spheroidal-celled acinous cancer (including the acute form, and the more chronic type known as scirrhus) and duct cancer. Colloid degeneration of either of the former varieties has been observed, but is very uncommon.

1. **Spheroidal-celled Acinous Cancer** includes the great majority of cases; the division into scirrhus and acute cancer depends clinically on the rate of growth and degree of hardness, pathologically on the greater or less amount of fibrous stroma present in any particular case.

Scirrhus usually commences as a hard circumscribed mass, situated most commonly in the upper and outer quadrant of the organ. It is closely united to, if not absolutely incorporated with, the breast substance, and on careful digital examination its margin is quite indefinite (Fig. 450). In the early stages it is entirely distinct from the skin, which moves freely over its surface; but as growth proceeds, the stroma contracts, and, by dragging on the suspensory ligaments of Cooper passing from the glandular substance to the skin, the latter structure becomes more or less fixed, and hence, on attempting to move it upon the tumour, an appear-

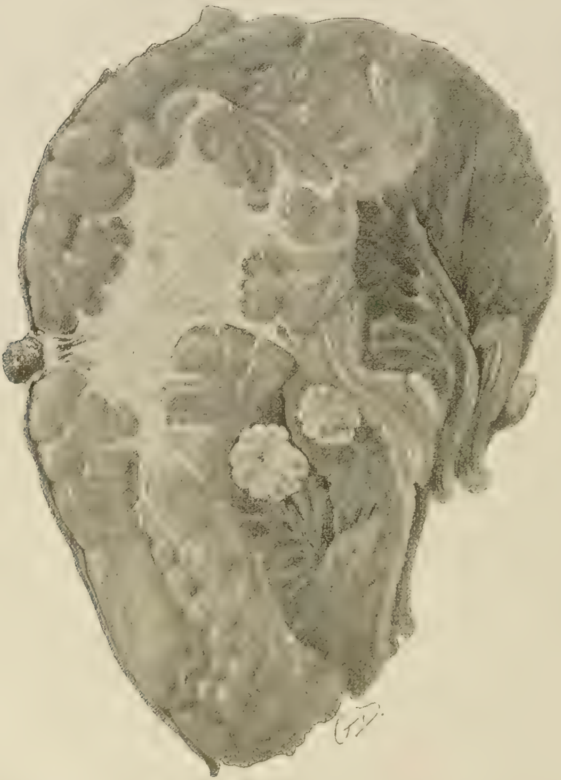


Fig. 450.—Section of Scirrhus of the Breast, showing Retraction of the Nipple, Infiltration of the Fat, and Secondary Nodules in the Underlying Muscles. (King's College Hospital Museum.)

ance of dimpling results. At the same time, the whole breast is acted upon in a similar manner, so that the affected organ sometimes seems to be smaller than the other; and, since the upper half of the gland is usually affected, the nipple may be drawn up so as to lie at a higher level than its fellow, as well as being retracted from the drag of the growth on the galactophorous ducts (Fig. 451). The tumour itself is rarely of great size, so long as it retains its scirrhous nature; it is sometimes extremely painful and tender, but not uncommonly the pain is intermittent, and of a neuralgic type, extending to the shoulder, and perhaps only elicited on manipulation. As the growth increases in size, it becomes adherent to the pectoral fascia, and may even infiltrate the underlying muscular substance, so that on examination, with the arm extended and abducted, it is found that, although moveable across the fibres of the muscles, the breast cannot be moved with them.

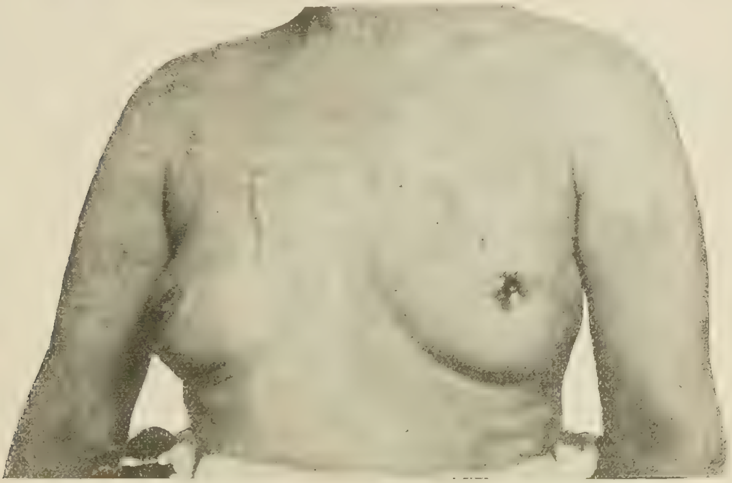


FIG. 451.—SCIRRHUS OF THE LEFT BREAST. (FROM A PHOTOGRAPH.)
The retraction of the nipple and its elevation above the level of the other are well seen.

The *lymphatic glands* in the axilla soon become enlarged, the disease rarely lasting many months without this complication. Those running with the long thoracic vessels under cover of the pectoralis major are first involved, and, as the case progresses, the remaining axillary and subscapular sets become similarly affected, and even after a time the supraclavicular. When the inner or deeper part of the breast is attacked, the disease may spread to the mediastinal glands along the lymphatics, which accompany the nutrient vessels arising from the internal mammary trunk; and thus intrathoracic deposits develop, which even extend along the subpleural connective tissue, and affect the pleural cavity and lungs. In those cases where the primary growth is situated near the inner border of the breast, the free lymphatic anastomosis across the middle line allows of the transmission of the disease to the glands in the opposite axilla, and sometimes a similar affection of the opposite breast arises from this cause.

The *skin* may be implicated in many ways. (*a*) The dimpling which is met with over the tumour in the early stages has already been mentioned. As the case proceeds, the cancer extends outwards along the suspensory bands of fascia, so that the skin itself becomes invaded, feeling firm and brawny, and looking congested and purplish in colour, whilst a branny desquamation is usually present. A crack or fissure at length forms, giving exit to a little serous discharge, which at first scabs over, but finally leaves an ulcerated surface, which slowly extends, and may attain considerable dimensions. A typical *scirrhous ulcer* is hollowed out and excavated; its surface, if kept clean, is covered with smooth granulations, discharging a considerable amount of sanious fluid, but if neglected, it becomes sloughy and offensive; it is surrounded by a projecting elevation of the tumour substance, forming a sort of rampart around it. (*b*) Less commonly the disease becomes disseminated through the lymphatics of the skin, giving rise to a series of firm cord-like thickenings radiating from the nipple (Fig. 452). The skin itself is thickened and firmer than

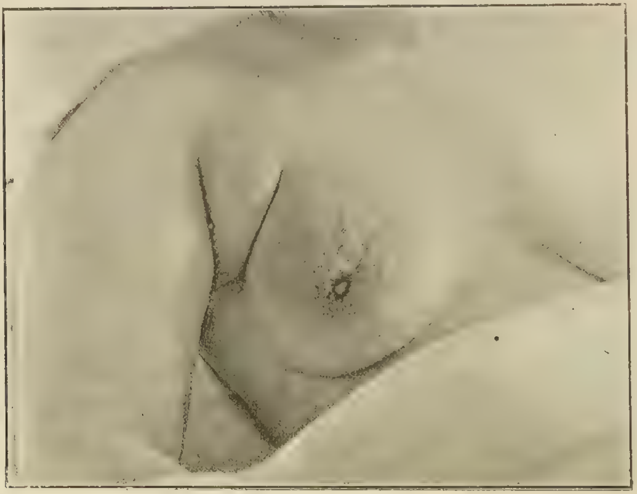


Fig. 452.—Diffuse Cancer of the Breast, showing Retraction of the Nipple, Infiltration of the Lymphatics of the Skin, and Swelling of the Arm due to Lymphatic Obstruction from Involvement of the Axillary and Supraclavicular Glands.

usual, so that it is impossible to pinch it up; the mouths of the sebaceous glands are enlarged and very evident, giving it a coarse appearance like 'pig-skin,' or the rind of an orange (*peau d'orange* of French authors). Later the colour becomes dusky, and numerous button-like nodules of cancer develop here and there; the sebaceous glands may exude an abundant secretion, which becomes inspissated on the surface into crusts or scabs, which are independent of any ulceration. This process often extends widely beyond the limits of the breast, invading the whole thoracic wall, and even running over the shoulder to the back of the head or neck (cancer *en cuirasse*); in its most typical form it is slow in development, the patient perhaps living for many years. (*c*) Occasionally one meets with a much more rapid form of cancerous lymphangitis, in which the skin becomes affected with what is supposed to be a 'weeping' eczema; the surface is red, hot, and infiltrated, and on examining it with a lens the dilated lymphatics can be seen from which the secretion oozes. The process spreads widely and rapidly, and cancerous nodules appear here and there in the infiltrated area; the prognosis is, of course, very grave.

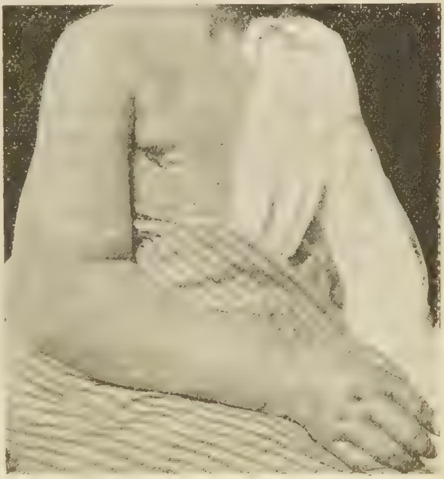


Fig. 453.—Lymphatic Œdema of the Arm Secondary to Carcinoma Mammæ, which had recurred after Operation.

In the later stages, the patient passes into a state of cachexia, becoming emaciated and exhausted. Ulcerated surfaces of considerable size may exist, and the tumour is fixed to the thoracic wall, even invading the ribs. The arm on the affected side is swollen and brawny, owing to the pressure of enlarged glands on the main lymphatics and veins of the limb, constituting a condition of solid or lymphatic œdema (Fig. 453). Severe neuralgic pain of the arm results from involvement of or pressure upon the brachial nerves in the supraclavicular fossa. Secondary deposits also develop in the viscera, especially the pleura, lungs, and liver, and may lead to various symptoms. Not unfrequently recurrence takes place in the connective tissue between the rib cartilages and the pleura, and nodules of growth develop, which may in time project forwards through one of the intercostal spaces (usually the second). Deposits in the bones (p. 596) are also not unusual, the sternum, vertebræ, and upper ends of femur and humerus being perhaps most often affected.

Severe pain is caused by such lesions, followed probably by spontaneous fracture, which may heal quite effectively or remain ununited. Finally, death from exhaustion ends the scene.

Acute Cancer is fortunately not common, and appears as a somewhat soft, rapidly growing tumour, which quickly infiltrates the whole organ, and gives rise to secondary lymphatic and visceral affections at a much earlier date than scirrhus. It does not cause retraction of the nipple or dimpling of the skin, the latter structure being distended, and with blue veins coursing under it. The breast becomes enlarged and prominent; the skin is stretched and gradually invaded by the tumour, and if ulceration follows, a foul fungating mass sooner or later sprouts up through the opening. This variety usually attacks young women under thirty-five years of age, and runs a rapidly destructive course, especially if it occurs during pregnancy or lactation, when it is likely to be mistaken for an acute mastitis.

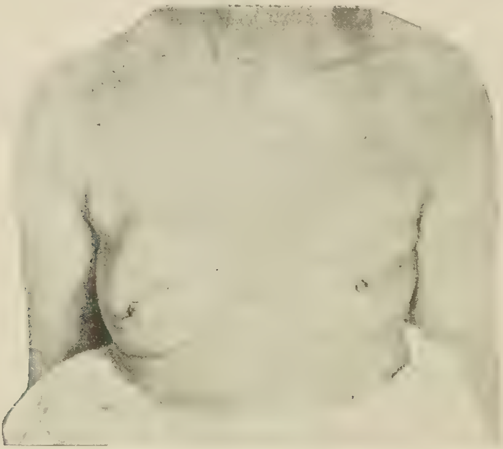


FIG. 454.—ATROPHIC CANCER OF BOTH BREASTS. (FROM A PHOTOGRAPH.)

The nipples are both retracted, and the skin around puckered and fixed to the growth. On the right side the axillary glands are obviously enlarged. The patient was an old woman over 70 years of age.

Finally, in elderly women, a chronic form of cancer is met with known as **Atrophic Scirrhus** (Fig. 454), in which the disease lasts for many years without much definite extension. Cases have been known to persist for fifteen or twenty years, the patient at length dying of some intercurrent malady, although in the great majority dissemination has ultimately occurred. The special characters are due to the excessive contraction of the stroma, as a result of which the cellular elements become crushed, and practically destroyed. The nipple is deeply retracted, and the tumour and breast substance in the most marked cases are scarcely discernible.

2. **Duct Cancer** is a somewhat rare form of the disease, the exact

nature of which is still uncertain, and there is very little doubt that several distinct types have been described under this name. It is sometimes characterized by the development of one or more nodules of a malignant papillomatous nature within the dilated ducts, and usually situated not far from the nipple. These growths are covered with columnar epithelium, and may, indeed, be looked upon as forms of columnar cancer. They are exceedingly vascular, and a blood-stained discharge from the nipple is usual. They always grow slowly, and when situated near the skin give rise to a round dusky red swelling. The nipple is not retracted, and lymphatic enlargement not constant. In other cases the dilated alveoli are occupied by masses of proliferated epithelial cells of a spheroidal type, which arrange themselves into more or less definite papillomatous growths, whilst cystic degeneration also occurs. Either of these varieties may be associated with a development of ordinary scirrhus in some other part of the breast. The diagnosis can only be established with certainty by microscopic examination after removal.

Adeno-carcinoma is the term given by Halstead to a condition very similar to the latter variety of duct cancer. The growth consists of tubular spaces heavily lined with epithelium; it develops slowly, but frequently fungates through the skin, and presents as a localized pedunculated growth, which readily bleeds. The axillary glands are usually free from infection, and the prognosis is good.

The **duration** of cancer varies considerably in the different forms The encephaloid type runs a rapid course, and will probably destroy the patient's life in six to twelve months. Duct cancer is very slightly malignant, whilst atrophic scirrhus is similarly slow in growth, and in both death may be postponed for a considerable period, or is often due to some intercurrent malady. Cancer *en cuirasse* is variable in its course, being sometimes tolerably rapid, and at others chronic; it cannot be cured by operation on account of its early and extensive dissemination. A circumscribed scirrhous tumour is stated to end fatally, on an average, in two or three years if no operative treatment is undertaken, whilst removal of the mass will probably add another year or eighteen months to the patient's life. These figures are, however, derived from statistics of operations performed before the general adoption of the more exact and extensive measures which are now usually undertaken, and it is likely that they underestimate considerably the benefits derived from such interference.

The **Pathological Anatomy** of cancer is discussed at p. 218.

The **Diagnosis** of scirrhus from *chronic interstitial mastitis* and *chronic abscess* or *cyst* has been already considered (p. 939). From *tumours of the adenoid type* it is easily distinguished. The stony hardness of a scirrhus, its union with the breast substance, its limited mobility, the dimpling of the skin, retraction of the nipple. and enlargement of the axillary glands, are the chief local characteristics to be noted. Non-malignant tumours are more elastic to the touch, more moveable, and usually quite circumscribed in outline, whilst the skin, though expanded, does not become adherent; the nipple is rarely retracted, and the axillary glands remain of normal size. It is often impossible to distinguish a cancerous from a *sarcomatous tumour*, except on microscopic examination; a round-celled sarcoma closely resembles an acute cancer, although it is usually more circumscribed—at any rate, in the early stages. A *fibro-sarcoma* may sometimes be mistaken for scirrhus, but it is more defined in outline, does not cause retraction of the nipple or dimpling of the skin, whilst lymphatic enlargement is not a constant accompaniment. A *cysto-adenoma* presents no difficulty in diagnosis if the skin is entire, and the cysts prominent; but when ulceration has taken place, and a fungating bleeding mass protrudes, it is not unlike the later stage of an encephaloid cancer or fungating round-celled sarcoma. It can be distinguished, however, by the fact that a probe can sometimes be passed under the skin for some distance into the cavity of the cyst, whilst lymphatic enlargement is rare. For the diagnosis of scirrhus from a tense *single cyst*, see p. 941.

Treatment.—This necessarily consists in the removal of the tumour by operation in all cases where there seems a reasonable chance of eradicating the disease. The only conditions that would contraindicate operation are extensive adhesions to the thoracic walls, the presence of visceral deposits, and extensive diffusion of a rapidly growing acute cancer in a young subject. Atrophic scirrhus is often left alone, on the plea that the prognosis is so favourable as to render operation unnecessary; if, however, the patient is fairly strong, there is no objection to it, and it certainly seems wise to remove a cancerous focus, however chronic it be. Disease of both breasts, although rendering the prognosis more grave, is, *cæteris paribus*, no hindrance, since both organs have been removed successfully, even at one operation. Speaking generally, rapidly growing tumours in vigorous patients are very unfavourable cases to deal with, whilst slow growth of the tumour, and definite limitation of its outline, are favourable signs.

In the old days, only the more prominent portion of the breast was removed with the tumour, and consequently recurrence was so extremely common that, if 5 or 10 per cent. of the patients were really cured, it was thought to be as much as any surgeon could reasonably expect. Since we have learnt more of the anatomy of the organ and of the evolution of the disease (for which we are mainly indebted to Heidenhain and Stiles), more extensive proceedings have been undertaken, with a gradual amelioration in the results, so that several surgeons have been able to report 50 to 60 per cent. of their cases as free from recurrence at the end of three years. It was suggested by Volkmann that any case which remains free from recurrence for three years may be claimed as a cure, but this is now generally considered too short a period, since the disease sometimes reappears at a much later date (even nine or ten years).

The breast is a much more extensive organ than was formerly supposed, its lobules extending upwards nearly as high as the clavicle, outwards into the axilla, and for some distance downwards, so that removal merely of the prominent part of the gland may leave much behind, and thereby favour recurrence. Moreover, the deeper lymphatics pass into the fascia covering the pectoralis major, and so to the axilla; hence, this structure should always be taken away, as well as a thin layer of the muscular fibres, but the wiser course is to remove the whole of the sternal portion of the pectoralis major, leaving only the clavicular. Many surgeons also remove the pectoralis minor muscle; this procedure certainly favours the axillary dissection, and does not seem to have any harmful influence on the subsequent movements of the arm. Again, lymphatics travel along the fibrous bands reaching from the breast tissue to the overlying skin, and thus this latter must never be dissected back from over the tumour. The nipple should under no circumstances be left behind, since all the interlobular lymphatics converge to a plexus around it, and thence pass to the axilla by three or four main trunks. The axilla itself should be opened in every case, and entirely cleared of its lymphatic contents, since deposits in the glands are often found on microscopic examination, where no clinical evidence of their presence had been previously noted. It is also important to remove the breast and axillary tissues in one piece, so as to avoid division of the lymphatics and possible infection of the wound with their cancerous contents.

Operation for Cancer.—The patient lies on the back, with the head directed towards the opposite side, and the arm raised to a little more than a right angle, so as to put the pectoralis on the stretch. An aseptic towel should be wrapped round the head, so as to keep the hair out of the way, and a similar sterilized towel may be placed below the chin on a cross-bar, to form a barrier between the anæsthetist with his apparatus and the field of operation. The axilla should be previously shaved, and the skin carefully purified. The incisions employed vary with the size and position of the tumour; the primary object is to remove the growth together with the whole gland and all its accessible lymphatic connections; the question of being able to close the wound subsequently is quite a secondary and minor consideration. As a rule, sufficiently wide undercutting will allow very extensive wounds to be closed; but when this is impossible, skin-grafting can be adopted, and no lengthy convalescence need ensue. Fig. 455 suggests the types of incision that may serve for the removal of tumours on the outer and inner sides of the breast respectively. Slight modifications will suggest themselves when the growth is in other positions.

When the incisions have been made, they are deepened, but not directly inwards. The skin around is dissected up so that the subcutaneous connective tissue may be removed together with the breast over a wide area extending as high as the clavicle above, down to the epigastric notch below, and behind the posterior border of the axilla on the outer side. The surface of the pectoralis major is then exposed throughout the whole length of the inner or upper incision, the connective tissue over it being turned downwards. The junction between the sternal and clavicular portions is defined, and opened up by finger and knife throughout its whole length. The insertion of the sternal portion is divided about an inch from the humerus, and then the finger is introduced under its origin from the sternum and costal cartilages, and this is severed by the knife close to the bone. Several perforating branches of the internal mammary will be divided in this procedure, and must be at once secured, so as to prevent their retraction through the intercostal spaces. The pectoralis minor comes into view, and is divided at its costal attachments and also close to the coracoid process.

The breast and underlying tissues can now be drawn downwards and outwards, thereby opening up the axilla freely; the next step consists in thoroughly clearing it. The main vessels are first defined below the lower border of the pectoralis minor close to the outer angle of the wound; a layer of fascia needs division in order to accomplish this. The dissection is then carried inwards along the vessels and nerves, which are freed from fat and glands both in front and behind, if necessary. Arterial and venous branches are best secured by ligature before division. If the glands are closely adherent to the vein, it is wise to excise a portion of it rather than to attempt to peel them off. The most careful search for glands must be made in the apex of the axilla, and in removing them every effort must be used not to rupture the glands by careless handling, as thereby dissemination of cancer cells may occur.

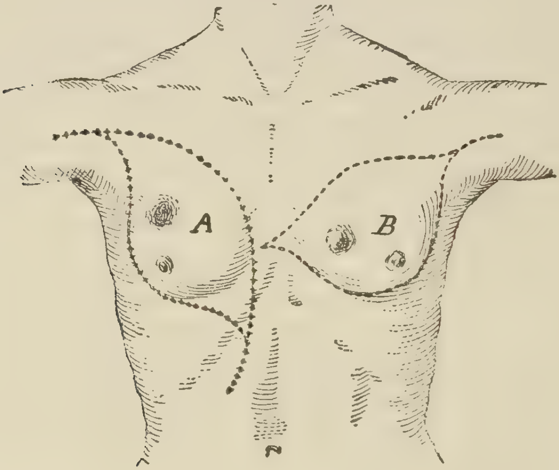


Fig. 455.—Incisions for Removal of Cancerous Breast when the Tumour is Situated in the Upper and Outer, or in the Inner Segment Respectively.

The surgeon next proceeds to remove the fat and fascia from the serratus magnus on the inner side of the wound, care being taken to secure the lateral branches of the intercostal arteries as they are divided, and to protect the nerve of Bell. The subscapularis is then cleared, and possibly the subscapular vessels may need division, but the subscapular nerves must be spared. Not unfrequently there are many enlarged lymphatic glands in this part of the axilla. When this has been effected, but little more remains to be done except to free the breast, pectorals, and connective tissue from their external attachments, and this is quickly accomplished by a few sweeps of the knife.

An enormous wound results, and during the later stages the exposed tissues must be protected as far as possible by covering them with warm sterilized cloths. Bleeding-points are secured, the wound washed out with hot sterile salt solution, and preparations made for closing it. Surrounding parts may need to be extensively undermined, or even plastic proceedings carried out in order to bring forwards redundant skin from the side and back. As a general rule the wound can be more or less completely closed by the exercise of a little patience and ingenuity. Under no circumstances should the upper part of the wound be left open, as thereby the axillary contents would be exposed, and harmful cicatrices might form. Should any part be left open, it is probably wise to defer a grafting operation till later. Deep tension stitches are often useful, and the margins of the wound are approximated by ordinary catgut or silk sutures. Drainage is usually desirable, and the tube may be placed through an opening made for it in the posterior axillary wall. A large and efficient dressing is applied back and front to receive the sero-sanguineous discharge, which is sure to be abundant. The arm is left at right angles to the side throughout the healing with the object of preventing the subsequent stiffness and limitation of movement, which was so marked formerly when the arm was bandaged to the side. The first dressing will be required in twenty-four or forty-eight hours, and the drainage-tube may then be removed. Healing should be complete in from ten to twelve days.

The immediate results of this operation are exceedingly satisfactory, the mortality being under 5 per cent. The ultimate results necessarily vary with the period at which the operation is undertaken, with the extent and character of the disease, and with the thoroughness and skill of the operator.

When the supraclavicular glands are enlarged, the operation must also include the supraclavicular fossa in its scope, as recommended by Halstead; he, indeed, goes so far as to maintain that the posterior triangle should be cleared of its lymphatic contents in all cases, whether or not enlarged glands can be detected beforehand, and states that in a considerable percentage cancerous invasion will have already occurred. Without going quite so far as this, we would advise that wherever there is much axillary involvement, the supraclavicular fossa should always be cleared. The cervical incision is a curved one, extending along the posterior border of the sterno-mastoid, and outwards along the clavicle. This flap is dissected up, and all the fat and glands are removed from before backwards, the internal jugular vein being the starting-point. Of course, the greatest care is taken to avoid the thoracic duct or right lymphatic trunk. Some surgeons have even proposed to divide the clavicle, but this seems to be a needless proceeding. The axillary and the supraclavicular wounds can easily be made continuous under the clavicle.

Local recurrence after operation is always due to incomplete removal of the growth, or to infection of the wound during the operation. The surgeon must ever keep in mind that although in a healthy organism the implantation of cancerous material has apparently but little or no effect, yet in a cancerous individual positive results are only too certainly obtained. The recurrence appears either in the neighbourhood of the cicatrix, the most usual situation, or in adjacent lymphatic glands, in the other breast, or in the retrocostal connective tissue. The progress is often slow, but occasionally the disease spreads more rapidly than if no operation had been undertaken. To prevent the likelihood of this, exposure to X rays after the operation may advisably be adopted.

Diffuse cancer of the skin *en cuirasse* is not suitable for operative treatment, but much may be done by exposure to the X rays (p. 56) or by radium.

It has been suggested to treat lymphatic or solid œdema by introducing subcutaneous strands of carefully sterilized silk from below upwards into the healthy tissues so as to act as artificial lymphatics. In some of the cases hitherto reported improvement has followed to a certain extent.

Some years back Beatson of Glasgow proposed to treat inoperable cases by double oöphorectomy and the administration of thyroid extract. Many patients have been dealt with in this way, and the results gained thus far show that, whilst a few cases have been apparently cured, in a much larger number no effect was produced, but that in quite an appreciable proportion the disease seems to have been temporarily controlled (perhaps for years), and the pain and discomfort very definitely diminished. The operation should of course only be undertaken in women who have not yet reached the climacteric.

Amputation of the Breast for *non-malignant* conditions is a very different operation to that described above. The incisions usually employed are crescentic and placed obliquely; they need not include much more skin than that indicated by the breadth of the areola. The integument is dissected up from the glandular tissue on either side, and the organ freed from its attachments to the pectoral fascia; the axilla is frequently not opened.

CHAPTER XXXV.

ABDOMINAL SURGERY.

General Remarks on Abdominal Operations.—No branch of the surgical art has grown so rapidly or attained such importance as that directed to the abdominal contents. Operations which formerly were advisably rare are now of everyday occurrence, and no surgeon hesitates to open the peritoneal cavity whenever it appears necessary, and even sometimes merely with the object of exploring the condition of its contents. Success is, however, entirely dependent on a minute and careful attention to details, which can only result from attentive observation and considerable experience. The peritoneum carefully treated is a good friend to the surgeon; it resents, however, rough handling or prolonged exposure, and serious inflammatory trouble may follow slovenly work, jeopardizing the patient's life, or even, if he live, giving rise to such disabilities and discomfort as may impair his usefulness. In no department of operative surgery is rapid and yet minutely careful work so well repaid. The following are a few points which may prove helpful to those aspiring to success in this important branch of surgery:

The patient should be *prepared*, when circumstances permit, by regulating the diet and bowels for some days previously, and thoroughly cleansing the teeth and mouth, so that the intestinal canal may be as free from organisms as possible; a course of internal antiseptics, such as salol, calomel, or β-naphthol, may be advisable. During the previous day an effective purgative is given—*e.g.*, 1 ounce of castor oil—and an enema may be desirable in the morning to ensure that the lower gut is empty. The abdominal wall is shaved, as also the pubes, and purified beforehand in the usual way, special care being directed to the umbilicus, where dirt is very liable to lodge.

No food should be allowed by mouth for three or four hours, and immediately before being placed on the table the bladder should be emptied, if need be, by catheter. If the proceedings are likely to be protracted, it is advisable to give a rectal injection of warm saline solution, or of beef-tea and coffee, half an hour beforehand, and possibly a hypodermic injection of strychnine (gr. $\frac{1}{100}$).

The patient should be warmly wrapped up and protected from cold, no unnecessary exposure being allowed. The operating room should be well warmed, and not below 70° F.; a temperature of

80° F., though trying for the surgeon and his helpers, is better for the patient. Complete anæsthesia is desirable, so as to diminish shock, but this should be obtained with as small a dose of anæsthetic as possible. Intraperitoneal operations are not painless, for although the visceral peritoneum is not acutely sensitive, yet the parietal layer is, as well as that included in the mesenteries, and any handling of these structures gives rise to pain and necessarily to increased shock, if the patient is conscious. If the patient is very collapsed before the operation, as in emergency work—*e.g.*, perforation of the stomach—it is often advisable to administer ether dissolved in saline solution by the intravenous method.

As a general rule the patient lies flat on the table, but if the operation involves the pelvic viscera, the *Trendelenburg position* is often adopted. In it the patient is placed with the head considerably below the rest of the body, which is more or less inverted (Fig. 456). The knees are bent over the end of the table, and help to keep the body in position. The head-piece of the table must be lowered, or the neck will be bent forwards into a position that impedes respiration. The arms must not be kept above the head, or musculo-spiral paralysis may follow; they are best placed behind the patient's back or close to the sides. This position must not be adopted when it is probable that the pelvis is occupied by a fluid inflammatory exudate, nor in conditions where obstruction is present, and the stomach is likely to be filled with offensive material which might gravitate into the mouth and suffocate the patient.

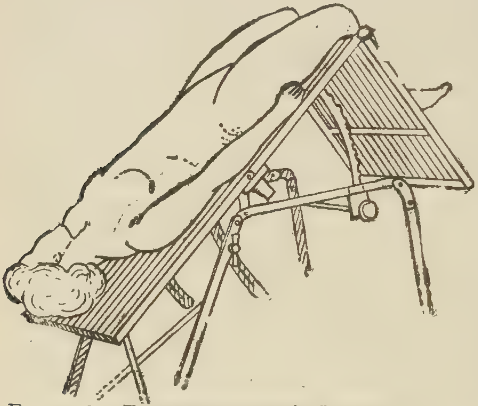


FIG. 456.—TRENDELENBURG'S POSITION FOR PELVIC OPERATIONS.

Antiseptics are avoided as far as possible in intraperitoneal operations; after efficient sterilization of the hands of the surgeon and his assistants and of the skin of the patient, nothing is employed in the shape of lotion except sterilized salt solution. Instruments are boiled previously and counted. Swabs are best done up in packets of a dozen, wrapped in gauze; it is thus easy to keep account of the number employed. Gauze strips for packing, abdominal cloths, etc., are dealt with in the same way; a careful record of the number employed must be made. If irrigation of the abdomen is required, warm salt solution is the best lotion to use for the purpose

Parietal Incision.—In planning the incision for any abdominal operation, three desiderata have to be kept in view: (i.) Suitable *access* should be provided to the part to be explored; naturally the middle line gives the best approach in the majority of cases, where a general exploration is desirable, and in many other conditions it is most useful. But when dealing with such structures as the appendix or gall-bladder, an incision placed laterally is usually more convenient. It is always well to remember that incisions should not be placed too near to the bony or cartilaginous boundaries of the abdominal wall. (ii.) It must be so placed as to ensure an *effective blood-supply*, and thereby avoid as far as possible the risk of defective union or a post-operative hernia. Naturally the middle line from this point of view is not always desirable, and the linea semi-lunaris is even worse. Particularly is this the case when the linea alba has been stretched, and the recti muscles separated one from the other. Perhaps the best incisions from this point of view are those which pass through muscular fibres, splitting and separating them, but not dividing them. MacBurney's incision for the removal of a quiescent appendix (p. 1053) is of this nature; it gives a sufficient approach when there are no adhesions, and when the appendix is not displaced. Should these conditions not be present, or if the patient is very stout, it will prove most inconvenient; a similar incision may also be used in iliac colostomy. Lennander's trap-door incision is somewhat similar in character. It consists in opening the sheath of the rectus in front, displacing the muscle in or out, and then making the incision in the posterior layer of the sheath, and through the peritoneum, so as not to correspond with that in front. (iii.) A point to which considerable attention has been given in recent years is the *nerve-supply* of the abdominal wall. As far as possible the incisions should be planned so as to avoid division of the motor nerves, especially those going to the rectus abdominis, inasmuch as paralysis of this muscle may result in considerable discomfort, and loss of tone of the abdominal wall may follow. From this point of view an incision through the linea semi-lunaris is one of the worst that could be devised. To avoid trouble of this type, various suggestions have been made which will be noted in the descriptions of different operations mentioned in this chapter.

Some surgeons have recommended a *transverse* incision of the abdominal wall, especially in dealing with pelvic lesions; the chief difficulty lies in gaining effective union of the divided ends of the rectus muscles. To prevent their retraction the fibres must be carefully stitched with mattress sutures to the anterior wall of the sheath before being divided; on the whole this method of approach has not commended itself to the majority of surgeons, and it is not much employed.

As far as possible the muscles and aponeuroses should always be cleanly divided, and it is wise to see that bleeding is stopped before opening the peritoneum; this membrane can usually be picked up by dissecting forceps, and opened with scissors or a knife; air rushes into the cavity, and it is easy to secure the margins with Spencer-Wells, or other suitable forceps. Holding these well up, the incision can be prolonged up or down as far as may be considered necessary.

The intestines must be carefully guarded during the intraperitoneal portion of the operation, as if they are unduly exposed to the air, the endothelial lining is quickly shed, and adhesions may form subsequently, whilst bacterial invasion from the gut is favoured. If they have to be withdrawn from the abdomen, they should be wrapped in cloths wrung out of warm salt solution, and it is the assistant's duty either to replace these from time to time by warm cloths, or better to keep them moist and warm by pouring fresh salt solution over them; no unnecessary handling of intestine is permitted. If any infective focus is to be opened, or the intestine incised, the surrounding parts must be carefully protected from infection by 'walling off' the area of operation; this is effected by surrounding it with abdominal cloths of suitable size and material, or strips of sterilized white gauze, wrung out of warm salt solution, or by placing them in directions where pus or other fluid might gravitate. A record of these must be kept, and it is wise not to cut any of them into smaller pieces. It is undesirable to use dry gauze for this purpose, as it is likely to stick to the intestine, and its removal may disturb the endothelial covering.

Closure of the Wound.—A careful toilette of the peritoneum must be undertaken before the abdomen is closed. All bleeding is stopped and blood-clot removed; swabs are counted, and, if thought necessary, the site of operation cleansed with sterilized salt solution at a temperature of about 105° F. Many different methods of closing the parietal incision have been adopted, but perhaps the best consists in first securing the peritoneum by a continuous catgut or silk stitch; then the muscular coats are approximated by deep interrupted stitches, either of purified silk or of catgut, which remain buried; and, finally, the skin is united by means of a continuous suture of catgut or silk, which is subsequently removed. In some parts it is difficult to secure the peritoneum separately, and then it is well to include everything except the skin by deep interrupted sutures, and some surgeons even include the skin in the grasp of these deep stitches.

Drainage is not usually called for in abdominal operations. If the surgeon is careful in his manipulations, and avoids measures which are liable to lead to subsequent oozing, the peritoneum may be closed with safety. When adhesions likely to bleed have been divided, or raw surfaces left such as occur after enucleating a parovarian cyst from the broad ligament, some means should be provided whereby any considerable effusion of fluid can escape, and this can often be best effected by the use of a rubber drainage-tube or a Keith's glass-tube, which can be removed in twenty-four hours. Into the latter it is perhaps as well to introduce a strip of aseptic gauze, which will act as a lamp-wick, and along which, by capillary action, the effusion finds its way into the general dressing placed over the wound.

On the other hand, when an infected focus has been opened and needs to be drained—*e.g.*, an acute appendix abscess—surrounding parts must be protected from the spread of infection, and this is best accomplished by the use of a rubber drainage-tube, around which sterile gauze is packed in such a way as to induce the formation of protective adhesions.

After - Treatment. — After the completion of the operation, the patient is replaced in bed with the head low; but this position need not be maintained for any length of time, and after a gastro-enterostomy, or in cases of diffuse peritonitis, it is better to place him in the Fowler position (p. 976) at once. If there is much shock, hot-water bottles are placed in the bed, and a rectal injection of hot coffee (4 or 5 ounces) is desirable. The continuous administration of hot saline solution *per rectum* is also inaugurated at once; this is best undertaken by employing an apparatus similar to that represented in Fig. 457. The fluid is kept at a temperature of 105° to 110° F. in a thermos flask, and allowed to escape through a suitable dripper into a tube which passes 6 inches up the rectum; the fluid is introduced into the rectum very slowly, so that it takes perhaps an hour and a half to administer a pint. This is generally tolerated very well, and may be continued for a day or two. It is of value not only to relieve shock, but also to make good the results of hæmorrhage, to allay thirst, and to assist in ridding the body of harmful toxic products by increasing diuresis and diaphoresis.

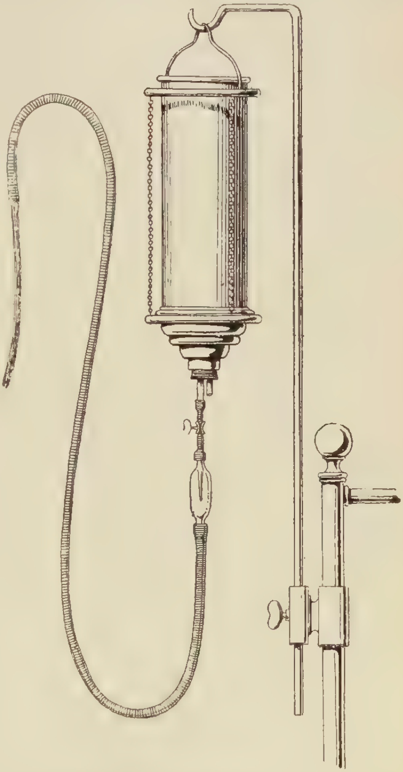


FIG. 457.—APPARATUS FOR SALINE INFUSION.

The flask to hold the fluid is supported by a bar fixed to the bedpost, and the rate of flow is regulated by the tap placed just below the flask and above the glass dripper.

Sedatives may be employed if the patient is restless or irritable, and a hypodermic of morphia (gr. $\frac{1}{4}$) or hydrochloride of heroin (gr. $\frac{1}{12}$) may be administered. Where there is no necessity to steady the bowel in order to gain adhesions, heroin is the better drug to employ, since its paralyzing effect on the secretions is so much less; but in some cases, where it is desirable to localize an infection, morphia is more suitable. At the same time it is important to use as little sedative as possible, and in not a few cases of simple operation, such as the removal of an appendix, it will suffice to introduce into the rectum, immediately after the operation, 30 grains of bromide of potassium and 15 or 20 grains of aspirin.

The *feeding* of abdominal cases has undergone a certain amount of change during recent years. There is no necessity to observe the prolonged abstention from food that used to be practised. Naturally, after the anæsthetic nothing is given by mouth for some hours, but if the patient does not complain of sickness there is no reason why fluids should not be administered after a short interval, and if the patient feels inclined to take his ordinary diet next day, this may be quite well permitted; in fact, the tendency of the modern surgeon is rather to look on a simple abdominal operation as merely an incident, and to interfere with normal nutrition as little as possible. In the more serious cases, especially with nervous patients where vomiting is likely to ensue, greater care must be taken. No food is permitted to enter the stomach for the day of operation, and then, when post-operative vomiting comes to an end, hot water in teaspoonful doses should alone be administered. Towards the end of the first twenty-four hours a little tea or albumin water, or milk and water, may be given, and gradually the diet may be increased. Special directions will be found for the feeding of particular cases, such as gastro-enterostomy, where the continuity of the intestinal canal has been interfered with.

Not uncommonly there is a good deal of discomfort and abdominal distension for the first day or two. This is usually due to a collection of flatus, which the patient is unable to expel. Relief is best obtained by the administration of a turpentine enema (1 ounce of turpentine to 1 pint of soap and water), which may need to be repeated. If the condition persists, and is accompanied by flatulence and vomiting (*peritonism*), suggesting the possible onset of peritonitis, the administration of a saline purgative—*e.g.*, 20 grains of sulphate of soda every half hour—or five doses of 1 grain each of calomel every hour, may stop the process by re-establishing peristalsis, removing bacteria and their products, and lessening the vascular tension. A hypodermic injection of strychnine or of eserine may also help by its direct stimulating action on the muscular coat of the intestine. Enemata containing castor oil (℥ii.) and olive oil (℥iv.), as well as turpentine (℥i.), are also sometimes employed.

The **Treatment of the Wound** requires no special attention. The stitches are generally removed at the end of eight or ten days, and the scar may then be supported by a collodion dressing or suitable strapping. External support in the form of a belt is sometimes thought desirable, and to be effective must be sufficiently extensive. Where there has been suppuration and the wound has healed by granulation, it is often desirable to keep the parts together by the use of strapping for some months, so as to prevent the abdominal muscles from dragging upon the scar and separating the united segments of the abdominal wall. For this purpose an unirritating zinc-oxide-rubber strapping is obtainable. Treatment of this type is much more effective than the use of a belt, and should particularly be employed after the draining of abscesses, and in appendicitis where the muscles have had to be divided.

Stitch Suppuration is a troublesome and irritating sequela of abdominal operations. It may be due to faulty technique, but occurs quite apart from this. The most careful sterilization of suture material will not always prevent its occurrence, and then it must be attributed either to tying the suture too tightly and strangling the tissue within its grasp, or to its becoming drawn too tight owing to post-operative abdominal distension, and to auto-infection of this strangled tissue, or of some collection of blood around it. Not a few cases have also been attributed to the employment of sutures taken directly out of spirit, which acted thereby as a caustic. All suture material should be carefully washed in sterilized salt solution or weak antiseptic lotion before using it for this purpose. The trouble may start early or late, and its occurrence is not unfrequently indicated by a slight but persistent rise of temperature (say, to 100° every night), associated, perhaps, with an increased rate of pulse. The external wound may apparently heal perfectly, and then ten or twelve days after the operation the cicatrix yields, and a quantity of pus may escape. Under these circumstances efficient drainage should be arranged, and if need be, the exposed stitches must be removed. Of course, this process weakens the abdominal wall, and extra precautions must be taken to prevent the formation of a ventral hernia.

Intestinal Sutures. -The interior of the bowel is occupied by material which, as long as it remains in its proper place, is innocuous enough; but should it find its way into the peritoneal cavity, an acute and often fatal peritonitis is almost certain to follow. Hence, every union made by the surgeon must be air- and water-tight, and capable of accommodating itself to varying degrees of intra-intestinal pressure. It is also essential that on its peritoneal aspect the line of union should present nothing but serous membrane, as otherwise adhesions are likely to form, and the comfortable action of the bowel may be subsequently impaired. Special forms of stitches have therefore been adopted, the more important of which are described below.

Lembert's Suture, originally proposed at the end of the eighteenth century, has for its object the bringing of surfaces of peritoneum together without encroaching on the mucous membrane; any stitch which involves the whole thickness of the wall is liable to be followed by leakage of the intestinal contents, and possibly by peritonitis. The needle is passed at right angles to the axis of the wound through a small fold of the serous and muscular coats, going down to the submucosa; each fold is placed about $\frac{1}{12}$ inch from the margin of the incision (Fig. 458). On drawing up and tightening the stitch, the margins of the wound are tucked in (Fig. 459), and only the serous coats brought into apposition. A series of similar stitches are inserted along the whole extent of the wound, numbering about ten or twelve to the inch, or it may be carried on as a continuous stitch. In closing a longitudinal incision in this way, a groove will be formed at either end which must be obliterated by two or three extra sutures. For a small puncture the same type of stitch is utilized, but it may be introduced circularly around the opening like a purse-string, and by tightening it the margins of the aperture are turned in and buried (Fig. 499).

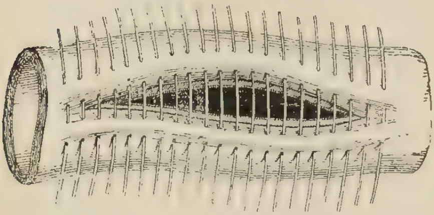


FIG. 458.—LEMBERT'S SUTURE AS APPLIED FOR A LONGITUDINAL WOUND OF THE BOWEL.

The stitches are carried well beyond the extremities of the incision, so as to obliterate the groove always caused by this method of suturing.

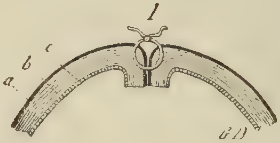


FIG. 459.—LEMBERT'S SUTURE SEEN IN SECTION, TO SHOW CHARACTER OF APPROXIMATION.

I., Suture; *a*, serosa; *b*, muscularis; *c*, mucosa.

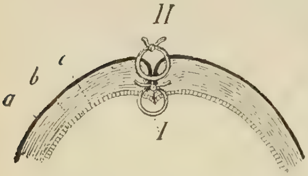


FIG. 460.—CZERNY-LEMBERT SUTURE.

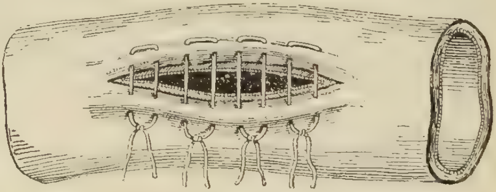


FIG. 461.—HALSTEAD'S MATTRESS SUTURE.

I., Stitch securing divided mucous membrane; II., ordinary Lembert suture, for the serous coats; *a*, serosa; *b*, muscularis; *c*, mucosa.

The *Czerny-Lembert Suture* is very similar in its nature, but consists of two rows: the first has for its object the closure of the wound in the mucous membrane (Fig. 460, I.), and in a longitudinal wound this may be of the continuous type; the second row consists of the ordinary Lembert stitches, continued or interrupted according to the requirements of the case (Fig. 460, II.). By this means the knots of the first series of sutures are covered over and buried by the second row. When carefully introduced, these stitches not only serve to approximate the divided walls of the intestine, but also are valuable hæmostatic agents, especially if inserted continuously.

Halstead's Mattress Suture (Fig. 461) is a very useful one, and constantly utilized. It consists practically of a double Lembert, a loop being thus formed at one end, whilst the knot is tied at the other. It is introduced with exactly the same precautions as the original Lembert.

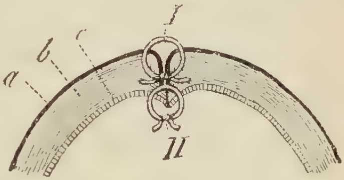


FIG. 462.—WOLFLER'S SUTURE.

I., Stitch through serous and muscular coat applied and tied from within; II., stitch uniting divided mucous membrane over the former, so as to cover it in; *a*, serosa; *b*, muscularis; *c*, mucosa.

Occasionally it happens that two segments of bowel have to be stitched together from inside, since the surgeon cannot reach the outer coats owing to this portion being fixed. Thus, in an exploratory gastrotomy it may be necessary to stitch up the posterior wall of the stomach after having opened it from the front. The stitches must then be inserted by what is known as *Wolfler's Method* (Fig. 462). They are first passed through the serous and muscular coats on either side (I.), the knots being tied on the inner aspect—*i.e.*, towards the lumen of the open viscus. The mucous membrane is then secured by a second row of stitches (II.), so as to cover over the first series of knots. In many forms of intestinal anastomosis this plan has also to be employed; as soon as possible, however, one changes to the Czerny-Lembert method.

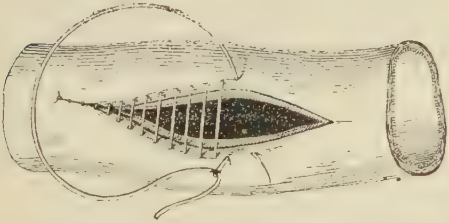


FIG. 463.—CUSHING'S RIGHT-ANGLED SUTURE FOR UNITING THE SERO-MUSCULAR COATS OF THE STOMACH OR INTESTINE.

For the sake of clearness the preliminary row of stitches through the mucous membrane is omitted in this diagram.

Cushing's Right-Angled Suture (Fig. 463) is a most useful one when surfaces of some extent have to be approximated by a continuous stitch. The suture is introduced at one end of the incision and tied according to the usual Lembert method, and then it is carried on as a continuous Lembert suture, except that the needle is introduced *parallel* to the margins of the wound and at a distance of about $\frac{1}{8}$ inch from it, instead of at right angles to it. The edges are thereby tucked in very neatly. Of course the mucous membrane is first dealt with separately by some form of continuous suture. It may be employed very advantageously in gastro-enterostomy or any similar procedure.

Injuries of the Abdominal Wall.

These may be divided into three main classes—contusions, non-penetrating and penetrating wounds; but, of course, the most important point about them is as to whether or not visceral complications are present.

Simple Contusions of the abdominal parieties differ but little from those of any other region of the body. Any form of lesion, from a slight bruise to an extensive muscular laceration, may be included in this category. The rectus is the muscle most often involved, and its laceration may result not only from injury, but also as a consequence of sudden and forcible contractions, *e.g.*, in tetanus. Blood is extravasated between or under the muscles, and a well-marked hæmatoma may follow. In connection with the rectus the hæmorrhage may be limited by the linæ transversæ if it only involves the anterior aspect, but may diffuse itself widely through the sheath if the back of the muscle is torn. All abdominal hæmatomata are very liable to suppurate, the abscess either pointing locally or burrowing widely between the muscular planes, and coming to the surface at some weak spot, *e.g.*, Petit's triangle or the external abdominal ring. The pus is usually redolent of the *B. coli*, suggesting that the organism found its way into the extravasated blood from some damaged coil of intestine in the neighbourhood. Occasionally the parietal peritoneum is torn, causing shock and intraperitoneal extravasation of blood. In almost all cases of abdominal contusion shock is an important early symptom, but in the absence of visceral lesions it is neither severe nor prolonged.

Treatment consists in keeping the patient in bed until the tenderness and pain have disappeared. Shock is dealt with in the usual way; and fomentations or a firm compress of dry hot wool will give much comforting support. Rupture of the rectus muscles necessitates the adoption of the sitting position, with the knees flexed over pillows: at a later date support, as by strapping or a well-fitting abdominal belt, will be required.

Non-Penetrating Wounds of the Abdominal Wall have no special significance, and if uncomplicated by visceral lesions are treated on general principles. If the epigastric artery is divided, extensive extravasation is likely to ensue; the wound must then be enlarged, and the bleeding points secured. If the abdominal muscles are widely divided, steps should be taken, after thorough purification, to draw together the severed muscular or aponeurotic fibres by deep stitches, so as to diminish the tendency to a ventral hernia.

Penetrating Wounds of the Abdominal Wall may occur with or without injury or protrusion of the abdominal viscera. In all cases there is a certain amount of hæmorrhage, greater or less according to the size of the vessels divided, and of shock, which latter is very marked when the viscera are injured, whilst mere protrusion without injury may cause but little effect. Thus, cases are on record in which a patient has walked to the surgeon for treatment, supporting some coils of intestine in his hands. The protruded viscera, usually small intestine or omentum, are often large in amount compared with the size of the opening, causing them to be more or less congested or even strangled. Necessarily, in all cases the great danger is that of diffuse septic peritonitis, caused either by rupture of the intestine or by infection from without.

Treatment.—The external wound is carefully cleansed, whilst protruding viscera are similarly purified. If omentum has escaped, it is wise to ligature and remove it, whether it is injured or not. Intestine should be carefully washed with warm saline solution and replaced; if slightly bruised, it may be returned, but the external wound should not be entirely closed, and a drainage-tube or gauze wick is inserted, so that if bacillary invasion or fæcal extravasation occurs subsequently a ready exit is provided. Small incisions or punctures must be infolded and sutured, but when small intestine is seriously damaged, enterectomy should be undertaken if the patient's general condition is sufficiently good; otherwise it must be fixed to the abdominal wall, and a temporary artificial anus provided. With the large intestine, this latter course is required more often, and especially in cases where the bowel is loaded with fæces; the gut must then be fixed in the wound as in colostomy, and the defect dealt with at a subsequent period.

In cases where it is not certain whether the peritoneum has been implicated, the surgeon should always enlarge the wound so as to make sure, and if the serous membrane has been involved, he should carry his investigations still further, and ascertain, if possible, whether any damage has been done to the viscera.

The external wound must (with the exception mentioned above) be carefully closed with sutures, so as to minimize the risk of a subsequent ventral hernia.

Visceral Complications are likely to be associated with any injury to the abdominal wall, and may transform it into a lesion of the gravest import. The liability to visceral injury varies with the character of the violence, and with the condition of the abdominal wall and of the subjacent viscera. If the blow is slight, the effects are probably not serious, and the patient merely suffers from a localized contusion with some amount of shock. If the blow is expected, and the muscles are rigid, but little harm may follow, even when the violence is great; but when the abdominal wall is relaxed and the blow unexpected, a slight injury may do much mischief. Hollow viscera, such as the stomach, intestine, or bladder, may be torn, and when distended they are more liable to such an accident. Solid viscera, such as the liver, spleen, or kidneys, may be bruised or torn, and grave hæmorrhage may result therefrom; a soft fatty condition of the organs, especially of the liver, may predispose to such a lesion. Displacement of organs may sometimes occur, and it must not be forgotten that any sudden sharp concussion, especially if directed to the epigastrium, is liable to be followed by severe shock from irritation of the subjacent solar plexus, and life itself may be destroyed in this way by syncope without the appearance of an evident lesion. The omenta, mesenteries, and peritoneal ligaments may also be torn, and give rise immediately to hæmorrhage, or subsequently to the formation of apertures or bands, which may determine obstructive phenomena at a later date. Thus, a blow in the epigastrium was followed by detachment of the round ligament of the liver from the falciform ligament, constituting a band which compressed the transverse colon.

The clinical history of these injuries will be described under the various organs, and only a few general statements need be made here. It is obvious that a serious responsibility rests upon the medical attendant in any case of abdominal injury, and that the gravest results may follow a mistaken conclusion as to the nature of the lesion, or a hesitant policy in undertaking operation. In a large proportion of cases abdominal injuries, even including rupture of intestine, are amenable to treatment by operation, if only it is performed sufficiently early; if, however, it is delayed until the gut is paralyzed and peritonitis well established, death is almost certain to ensue whether the abdomen is opened or not. Unfortunately, no absolute rules can be laid down as to when operation is necessary, but the surgeon should remember that exploration in a doubtful case will probably do far less harm than by waiting until the diagnosis is made certain by an outbreak of diffuse inflammation, providing always that the patient is not so profoundly collapsed as to contra-indicate all interference.

Cases of serious abdominal injury group themselves into three sets: (1) Where, in addition to a localized lesion of the parietes, there is severe shock due to contusion of viscera, but with no justification for laparotomy; (2) where there is serious intraperitoneal hæmorrhage, as from a ruptured liver or spleen, or a tear of the mesentery; and (3) where a hollow viscus is opened, and peritonitis is at once lighted up.

Shock is almost always well marked in abdominal lesions, but unless there is a serious wound of some viscus, it usually passes off in less than twenty-four hours if the patient is left quietly in bed. *Intraperitoneal hæmorrhage* causes various symptoms according to its amount and site of origin; in addition to the initial shock, the general signs characteristic of this condition show themselves, viz., pallor, restlessness, 'air-hunger,' and possibly the large-waved hæmorrhagic pulse. Dulness may be noted in one or both flanks, according to the situation of the lesion, being influenced by the attachment of the mesentery; thus blood from the liver may gravitate into and for a time be limited to the right lumbar region and iliac fossa without reaching the pelvic cavity; blood from the spleen will pass freely down into the pelvis along the left side of the mesentery, producing dulness in the left loin and not in the right. It must be remembered, however, that a large quantity of blood may escape into the peritoneal cavity without the production of any recognisable area of dulness; it is then lodged under the costal arch, or amongst the intestines, or in the pelvis. When the bleeding is less severe, the patient complains of a severe tearing pain, becomes pallid and anæmic, but may recover, and the blood be absorbed; not unfrequently the temperature runs up after the initial shock has passed, and remains up for some days. The onset of *peritonitis* is indicated by persistence of the collapse, and vomiting or hiccough, whilst the abdomen becomes distended, its wall is held rigidly steady, and the breathing becomes thoracic; probably some fixed spot of maximum tenderness will be noted, especially when the intestine is injured.

Treatment.—The patient having been put to bed, and the initial shock combated in the usual way, a most careful examination of the patient and his abdomen is instituted. Conditions which indicate immediate operation are: (*a*) the signs of intraperitoneal hæmorrhage; (*b*) blood-stained vomiting, indicating a rupture of the stomach; (*c*) a fixed and rigid abdominal wall coming on quickly after an injury, with severe pain and localized tenderness, suggesting a rupture of the intestine; and (*d*) the phenomena due to a ruptured bladder. Under such circumstances, no delay is justifiable, and, even if severe shock is present, operation should be commenced, unless death is evidently imminent. A large intravenous injection of hot saline solution will usually rally the patient sufficiently to warrant the surgeon in proceeding, or better still, ether may be administered by the intravenous method. If, however, well-marked shock is present, with perhaps localized pain, but with no absolute evidence of visceral lesions, expectant treatment should be adopted. The patient is kept warm in bed; perhaps a little opium is administered to allay pain and restlessness and to check peristalsis, but as little as possible should be given, since symptoms are so completely masked thereby. If there is any vomiting, rectal alimentation should be employed after the lower bowel has been washed out. If the manifestations of intraperitoneal hæmorrhage subsequently make themselves evident, or if at the end of not more than twenty-four hours the patient is still, more or less, in a condition of collapse, and especially if he complains of a fixed tender spot with a rigidly contracted abdominal wall over it, or if vomiting or hiccough has supervened, then operation can still be undertaken with some prospect of success.

There are but few other conditions of the abdominal wall which require notice. The rectus muscle may be torn as a result of injury or of tetanic convulsions, and a hernia is very likely to follow. One of the segments may become spasmodically contracted, constituting what is known as a 'phantom tumour,' usually occurring in hysterical females, and disappearing under an anæsthetic.

Affections of the Umbilicus.

The various forms of umbilical hernia are described elsewhere.

Inflammation and **Ulceration,** perhaps running on to eczema, may arise from want of cleanliness after separation of the cord. Tetanus neonatorum probably owes its origin to this source, as also the erysipelas of infants, both of which diseases are exceedingly fatal, whilst the latter is often accompanied by sloughing of the neighbouring abdominal parietes. The eczematous condition merely requires cleanliness, and the application either of an antiseptic dusting-powder or of some simple ointment. In adult life inflammation is occasionally seen as a result of the accumulation of dirt in the umbilical fossa; this accumulates at times to such an extent as to constitute a *calculus*, which gives rise to suppuration and ulceration.

Occasionally a **Polypoid Excrescence** is met with growing from the umbilicus, and is probably derived from the remains of the umbilical vesicle. On microscopic examination, it is found to consist of a number of tubular glands held together by connective tissue. All that is needed is to ligature the base and cut it away.

Warts and **Nævi** are also found here, but have no special features. **Cancer** of the umbilicus may be primary, occurring either as a squamous epithelioma, starting in the skin as a result of prolonged irritation, or as a columnar carcinoma, arising in some fœtal relic. More frequently it is secondary to some deep abdominal focus, such as cancer of the stomach or ovary.

Umbilical Fistulæ not unfrequently occur, and may be congenital or acquired. Three varieties are described:

(*a*) A *Fæcal Fistula* of congenital origin arises from non-closure of the vitello-intestinal duct, and opens into the intestine either directly, or by means of a passage of greater or less length, which corresponds to Meckel's diverticulum, and is connected with the lower part of the ileum. Sometimes this passage is closed at the intestinal end, and then only discharges mucus. Acquired cases are usually due to perforation of the bowel following strangulation of an umbilical hernia, or to tuberculous peritonitis.

(*b*) A *Congenital Urinary Fistula* is due to non-closure of the urachus; occasionally merely a sinus persists, leading towards the bladder, but not opening into it. It may be dealt with by excision of the mucous membrane, its destruction by the galvano-cautery, or by freshening the edges and subsequent suture.

(*c*) A *Biliary Fistula* sometimes forms at the umbilicus, resulting from an abscess connected with the gall-bladder.

Affections of the Peritoneum.

Peritonitis arises from many different conditions and presents many diverse manifestations. It may be acute or chronic in its course, localized or diffuse in its distribution, and protective or rapidly destructive in its results.

Ætiology.—Peritonitis is almost invariably due to the action of micro-organisms, and the symptoms largely depend on the toxæmia determined thereby. The bacteria light up an inflammatory reaction characterized by effusion of varying type; in the mildest forms it is usually abundant and localized, in the severer types it is generalized, and in the worst cases death may ensue from toxæmia before there has been time for the development of marked anatomical changes.

1. Infection may start from any part of the intestinal canal or its adnexa, included in the abdomen, from stomach to rectum. It may be due to traumatic or pathological rupture or perforation, to the extension outwards of ulcers, to the impaction of foreign bodies, or the damaging influence of interference with the blood-supply, as in strangulation, volvulus, etc. The vermiform appendix is the commonest site of onset of this group of cases. The *Streptococcus pyogenes* and *B. coli* are the organisms most frequently present, but some of the other inhabitants of the intestine, especially those that are anaërobic, are occasionally causative. On the whole the gastric contents are less noxious than those of the intestine, and the fluid contents of the small gut are more liable to be diffused, and therefore do more harm than the more solid fæces in the large.

2. A somewhat similar type of origin causes *puerperal peritonitis*, the organisms (usually streptococci, but of any pyogenic form) extending from the uterus through the lymphatics of the broad ligament, etc., to the peritoneum; it is therefore possible for the mischief to limit itself to the pelvic viscera.

3. Infection may occur from without, as in perforating wounds, operations, etc., any of the ordinary pyogenic organisms being responsible, but especially the streptococcus. The likelihood of infection depends largely on the peritoneum remaining unbruised; rough handling and prolonged exposure are only too likely to destroy the surface endothelium and diminish its resisting powers, whilst the same conditions check the power of absorbing fluids, and hence permit of bacterial growth.

4. Peritonitis may be due to the *gonococcus*, and then has usually spread up the Fallopian tube (p. 982); to the *pneumococcus*, probably as a blood infection, or secondary to pneumonia or pleurisy, the bacteria travelling through the lymphatics of the diaphragm (p. 982); and possibly to the organism of *acute rheumatism*, then, perhaps, starting in the appendix.

5. The *B. tuberculosis* is responsible for the development of a chronic tuberculous peritonitis.

6. Simple chronic peritonitis is of a protective character, and arises when any irritative lesion of a viscus slowly approaches the peritoneal surface, which becomes thickened in consequence. Adhesions of various types may result from this reaction, and grave developments (obstruction, strangulation, etc.) may follow at a later date.

7. A group of cases occurs in which the causative lesion is mechanical or chemical in the first place—*e.g.*, extravasation of bile from a ruptured gall-bladder, or the irritation produced by torsion of a wandering spleen, of an ovarian cyst, or even of the omentum. Severe reaction follows such a lesion, but it is possible that the focus

may be shut off from the general cavity by plastic adhesions, and be thereby encapsuled or absorbed; or the inflammation may extend to neighbouring coils of intestine, and when once these become paralyzed bacterial invasion is almost certain to follow, and septic peritonitis to ensue.

It is interesting to note that a localized immunity can be developed in the peritoneal cavity of animals by injecting gradually increasing doses of toxic material; it is probable that a similar condition obtains in man, and this explains why the sites of old peritonitic trouble are often favourable for operations, an attack of generalized inflammation being unusual.

Varieties.—From a purely clinical standpoint, peritonitis may be discussed under two main headings—the acute and the chronic. The acute is again divided into the diffuse and localized, and the chronic into the simple and the tuberculous.

1. **Acute Diffuse Peritonitis** results from infection of the peritoneal cavity with a large dose of infective material (as by rupture of the stomach or intestine), or by the introduction of a small dose of virulent organisms when the resisting powers are low.

Pathological Anatomy.—The peritoneal surface becomes congested and a little sticky, and its shiny appearance is lost as a result of the proliferation of the endothelial cells and a commencing œdema of the subserous connective tissues; this change is most advanced in the neighbourhood of the site of infection, but rapidly spreads, and in the gravest forms of peritoneal toxæmia, where death takes place under twenty-four hours, there is but little other evidence of the disease. In the great majority of cases, however, effusion occurs; sometimes the fibrinous element is most marked, the intestines being matted together, and the fibrin thickest along the lines of contact of adjacent coils; sometimes there is an abundant serous exudation, but more frequently it is sero-purulent or consists simply of pus, which may gravitate to the loins and pelvis, or travel upwards under the diaphragm, or be shut up in pockets by the development of adhesions. The effusion is intensely infective, and the surgeon should always protect his hands by rubber gloves, since any wounds caused during operation or in the post-mortem examination are likely to be followed by severe cellulitis or even septicæmia. Gas may be present, resulting either from the laying-open of an air-containing viscus, or from the presence of a gas-producing organism.

The intestinal walls become paralyzed, as a direct result of the toxins upon the contained nervous plexuses, and in consequence the contents of the gut stagnate and undergo decomposition. The omentum becomes congested and infiltrated with effusion, or even pus; it may occasionally, however, form a barrier across the abdomen, shutting off the lower from the upper part, and thus limiting the mischief to one or other section.

The toxins developed in the exudate are absorbed by the peritoneum, and whilst causing a generalized toxæmia of varying severity, they may also determine a well-marked subperitoneal œdema. The rapidity of absorption is very considerable, especially from the under surface of the diaphragm, where the lymphatics are practically continuous with the peritoneal cavity, and quickly carry toxins and bacteria to the mediastinal glands. The upper half of the abdomen is therefore a less favourable site for peritonitic trouble than the lower, and all available means, such as position, drainage, etc., must be employed to limit or prevent the extension of the trouble in this direction.

Symptoms.—The onset varies somewhat with the cause of the affection; but when due to traumatic infection from without, the symptoms usually commence with abdominal pain and distension, together with flatulence and vomiting. The pain may be localized at first to some particular region, or is referred to the umbilicus; soon, however, it becomes diffuse, and is associated with exquisite tenderness and great distension. In a typical case the phenomena are very characteristic. The patient lies on his back with the knees drawn up, partly to relax the abdominal muscles, partly to prevent the bedclothes touching the body. The abdomen is distended, hard, and extremely tender; it is at first generally tympanitic, but later on, if effusion should become marked, dulness may be noted in the flanks, although this is not a common feature. The pulse is quick, hard, and wiry in the early stages, though later it becomes weak, rapid, and compressible. The respirations are quick, shallow, and thoracic in character. The temperature, perhaps raised at first as a result of the causative lesion, sometimes becomes subnormal from toxæmia before the end is reached. Vomiting is usually a prominent symptom, associated perhaps with hiccough; to commence with, the contents of the stomach alone are expelled, but later on they may be mixed with bile, or with the decomposing contents of the upper coils of intestine. Though very constant and troublesome, it is much less distressing than that which arises from intestinal obstruction, and, owing to the pain induced by any sudden contraction of the abdominal muscles, the patient ejects the vomit with but little force. Constipation and the absolute arrest of flatus are almost always present in peritonitis, owing to the cessation of peristalsis induced by the inflammation, and hence meteorism is a marked symptom. As the case progresses, the patient's strength rapidly diminishes, his face becomes pinched and drawn (*facies Hippocratica*), the extremities are cold, the temperature is usually subnormal, and death results from collapse and toxæmia.

When due to sudden perforation of the bowel, the onset of the symptoms is associated with profound shock, and the course is very rapid if the opening is large, and the intestinal contents early extravasated. Vomiting, too, is usually more marked than when due to other causes. If, however, the perforation is small, the immediate shock is less, and the symptoms progress more gradually.

As already mentioned, there are certain grave cases in which the general toxæmia is the most marked phenomenon, and these may succumb from exhaustion in from twelve to twenty-four hours. The majority of cases, however, last for three or four days. Recovery is heralded in by a diminution or cessation of the vomiting and the passage of flatus, whilst the pulse-rate falls, and the local symptoms gradually clear up.

Treatment.—In the early stages, if the diagnosis is in doubt, or the desirability of operation is in question, the patient is kept quietly in bed, and preferably in what is known as Fowler's position (Fig. 465)—*i.e.*, with the head and trunk raised from the horizontal plane about 30° or 40°, so as to determine the flow of fluid exudate down towards the pelvis rather than backwards into the kidney

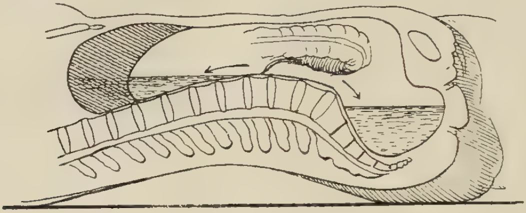


Fig 464.

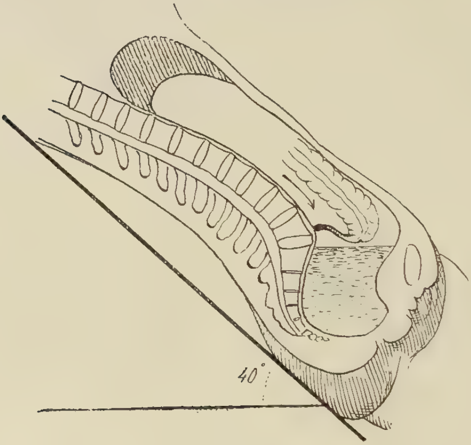


Fig. 465.

Figs. 464 and 465.—Diagrams to Represent the Value of Fowler's Position in the Treatment of Inflammatory Affections within the Abdomen.

In Fig. 464 the patient is horizontal, and it is obvious that an inflamed appendix lying over the brim of the pelvis will cause effusion, which drains in two directions: upwards towards the liver (shaded dark) and diaphragm, and downwards to the pelvis. In Fig. 465 the body is in Fowler's position, and the resulting effusion will collect in the pelvis.

pouches, whence it may spread up to the dangerous subdiaphragmatic area. No food is administered by the mouth, and no purgative given; the lower bowel may be emptied by enema, and subsequently saline injections administered to relieve thirst. Morphia and opium are used with the utmost caution as long as the diagnosis is uncertain, for fear of masking symptoms. By determining a cessation of vomiting and a false sense of comfort, unjustified hopes may be encouraged, and delay in operation result; at the same time they may be useful in localizing the trouble and allowing adhesions to form. Whilst the patient is being prepared for operation and the necessary arrangements are being made, a moderate dose of morphia may save him much suffering and help to conserve his powers.

The actual scope and particular features of the operation vary naturally with the many causes that may have been operative in determining the outbreak of the condition, and these will be suitably referred to afterwards. It is only possible here to deal with the general features. The incision is made in the linea alba, unless the causative lesion is obviously on one side, as in the case of a perforated appendix; and the lower half of the abdomen is opened rather than the upper, unless the latter is distinctly indicated. The objects of the operation are threefold: (1) To find and deal with the cause of the affection, such as a perforation which needs to be closed, or a perforated or gangrenous appendix which must be removed. (2) To cleanse the peritoneum and remove the effusion. Some surgeons rely on mopping up the exudate with dry sterile swabs, and if it is localized, and not diffuse, this may act excellently. When, however, there is a considerable sero-purulent effusion, occupying the pelvis, and perhaps spreading up through the kidney pouches to the under surface of the diaphragm, irrigation of the cavity is probably desirable. Sterile salt solution at a temperature of about 107° is used, and the whole proceeding should be effected without the escape of much of the intestine. Counter-openings in the loins or above the pubes may be required to give exit to the fluid, and then the end of a sterilized rubber tube coming from the irrigator is carried here and there through the abdomen by the hand, and the exudate effectively washed out through glass or rubber tubes placed in the various incisions. It is most undesirable to allow the escape of many coils of intestine, and general evisceration with the object of cleansing the intestines adds seriously to the shock, and usually does more harm than good. 'Quickly in and more quickly out' is an ideal that ought to be striven after. It must be remembered that the peritoneum has a considerable power of absorption, and unless the inflammation has gone very far, this may be relied on to a considerable extent to deal with inflammatory exudates, which are not frankly purulent. (3) Drainage is necessary in almost all cases, and may be effected by the use of glass or rubber tubes with or without gauze wicks. When employing a Keith's tube, the enclosed gauze wick is removed twice a day, and any effusion lying at the bottom sucked up through a sterile rubber catheter attached to the nozzle of a glass syringe. It is probably wise to omit the glass tube at the end of forty-eight hours, and replace it by a smaller and shorter rubber tube, which in turn is followed by a gauze drain as soon as the discharge diminishes sufficiently. The abdominal wall is, of course, only partially closed after these proceedings.

When intestinal distension is very great, so that it may be difficult to reach the cause of the trouble or to return the extruded viscera, it may be advisable to tap a coil of small intestine and empty the contents, or to stitch in a rubber tube and allow the bowel subsequently to empty itself, dealing with the fistula so produced at a later date. The reduction of the distension is an essential element if a successful issue is to follow, but undue manipulation must be avoided. If the bowel is merely tapped and at once closed, it may be advisable to follow the plan suggested by McCosh of injecting several ounces of a saturated solution of Epsom salts before closing the abdomen. With the same end in view the hypodermic administration of strychnine or eserine may be employed after the operation with the idea of stimulating the unstriped muscle fibres of the intestinal wall.

As soon as the patient has recovered from the anæsthetic, he should be raised from the recumbent to the sitting posture (*Fowler's position*), with a view to permitting the fluid effusion to gravitate into the pelvis. Continuous infusion of salt solution into the rectum (*proctoclysis*) or subcutaneous tissues should also be employed in order to dilute the toxins and facilitate their elimination (p. 963). For infusion into the subcutaneous tissues the outer side of the thighs will be convenient. Two needles are introduced, only one of which is used at a time. Four or five ounces are injected on one side, and then the other limb is employed; the needles are kept in place whilst the fluid is being absorbed. Improvement in the condition of the patient shows itself almost at once by a fall of temperature and of pulse; the vomiting ceases or becomes less urgent, pain and tenderness decrease, and the patient looks and feels better. On the second day the bowels are likely to become distended with flatus, and it is necessary to obtain relief; this is best effected by a turpentine enema in the first place, followed by a dose of castor oil, or of sulphate of soda, or repeated small doses of calomel. As soon as the bowels have acted well, the urgency of the symptoms diminishes, and it is probable that the patient will recover.

The wound requires constant dressing for some time, as there will be a good deal of discharge, and perhaps the fatty and fascial margins of the wound will slough. The tubes are gradually dispensed with as the discharge diminishes, and replaced by gauze drains; and when the deeper tracks have filled with granulations, the superficial wounds may be drawn together with strapping, and thus the strength of the abdominal wall may be maintained. It will be wise to order an efficient belt or support after operations of this type.

2. **Acute Localized Peritonitis** usually arises in connection with some limited lesion of the abdominal contents, which is of such a nature as to permit of the general peritoneal cavity being shut off by adhesions, the process being thereby localized. It is frequently followed by suppuration, the abscess being thus intraperitoneal, although not involving the general peritoneal cavity. The abscesses arising in connection with appendicitis or pelvic peritonitis are not uncommonly of this nature. They may burst through the barrier of adhesions, and thus light up a diffuse inflammation of the peritoneal sac, or they may burrow to the surface and point externally, or open into one of the hollow viscera.

The **Symptoms** complained of are deep pain and tenderness, more or less localized to the affected area, together with fever, vomiting, and constipation. At first no swelling or tumour is to be made out, but a feeling of resistance may be noticed in the abdominal wall, which is held tense and rigid, as if guarding some focal point of mischief. As the effusion increases in amount, a tumour dull or tympanitic on percussion may become evident; it is mainly due to a matting together of the intestines and omentum, but is often associated with a variable amount of effusion; if, however, it is placed deeply, the dulness may be absent owing to the fixation of one or more coils of intestine in front of the inflammatory focus. If an abscess forms and travels towards the surface, the abdominal wall becomes infiltrated, red, and œdematous, the component tissues being brawny to the touch, and cutting like bacon. Finally, a fluctuating area presents itself in the midst of this indurated mass, and the abscess either discharges itself or is opened. The pus contained therein is often offensive, owing to the presence of the *B. coli*. Of course this process is attended with considerable increase in the pain and constitutional disturbance. If the cavity is opened aseptically and drained, it rapidly contracts and a cure is accomplished, although intraperitoneal adhesions may persist and lead to subsequent trouble from hampering the intestinal movements. If a communication is established with the intestine, a fæcal fistula is apt to follow; whilst if the cavity becomes septic, chronic suppuration may result, and thereby the patient's health and strength are undermined. The determination as to the existence or not of suppuration is by no means easy, and a blood count, perhaps repeated more than once, is often of the greatest value (see p. 62).

Treatment.—In these cases resolution can sometimes be obtained by keeping the patient absolutely quiet and on a low diet, with perhaps a little morphia, and by applying fomentations locally, whilst the lower bowel is emptied by an enema. Such a course must, however, not be persisted in for too long when suppuration is likely to have occurred, for fear of the inflammation spreading to the general peritoneal cavity, or of the abscess bursting into it. An early exploratory laparotomy is advisable under such circumstances. The line of treatment marked out for appendicitis (p. 1056) is that which should always be followed.

3. **Simple Chronic Peritonitis** in itself rarely requires surgical attention, since it is to be looked on rather as a protective than as a destructive process. It is characterized by infiltration and thickening of the peritoneum, whereby the intestinal wall is strengthened and bacterial invasion hindered. It is localized or diffuse in character, and arises as the result of some pre-existing inflammation. In the more diffuse forms the intestines may be hopelessly matted together, or the omentum rolled up and contracted into a rounded cord-like mass, lying transversely across the upper part of the abdomen; chronic obstruction is almost certain to arise sooner or later from this condition.

More frequently it is the consequence of some localized injury or inflammation. In the former plastic lymph is deposited over any breach of continuity of the serous membrane, and to this the omentum or intestine becomes adherent; the under surface of a laparotomy wound is not unfrequently affected in this way. Localized areas of inflammation are similarly liable to originate adhesions, which are thus found in connection with gastric ulcers, an inflamed vermiform appendix, enlarged mesenteric glands, or a pyosalpinx. Under favouring circumstances many such adhesions are absorbed in the early stages; but if they persist, they are modified by the intestinal movements, and are likely to become lengthened and rounded, thus originating the bands and cord-like structures so often the causes of acute obstruction. The anatomical arrangements of the omentum explain why this structure is so frequently involved in this process, and thereby it constitutes one of the most important agents for checking the spread of inflammatory affections. Intestinal adhesions often give rise to no symptoms; but sometimes they determine attacks of colic and of irregular peristalsis, and occasionally an adhesion to the abdominal wall—*e.g.*, one springing from the stomach—causes a localized constant pain which justifies exploration.

4. **Tuberculous Peritonitis.**—This disease is almost limited to young people, and is usually secondary to some other focus of tuberculosis—*e.g.*, in the intestine, mesenteric glands, Fallopian tube, testis, etc. It is sometimes limited in its development to a portion of the peritoneal cavity, especially when originating from the pelvis or vermiform appendix, but is more frequently diffuse. It manifests itself in several different ways, which may be associated with or follow one another: (1) In the *ascitic* variety the peritoneum becomes thick and hyperæmic, and is studded over with tubercles, some of them small, gray and translucent, others larger and undergoing caseation. The effusion is generally abundant, and consists of straw-coloured or opalescent serum, perhaps blood-stained in the more active cases. Flakes of fibrin may be found covering the membrane here and there, but there is no extensive matting of the intestines. Occasionally the effusion becomes *encysted*, giving rise to localized fluid swellings shut in between the coils of intestine. (2) In the *fibrous* variety the intestines are matted together by extensive adhesions, and between

them foci of tubercle are found. The mesentery may become infiltrated and shrink, fixing the intestines back *en bloc* to the posterior abdominal wall. The omentum is often invaded, and contracts upwards to form a sausage-like tumour lying transversely above the umbilicus. There is but little effusion, and that is usually encapsuled. It is obvious that such a condition is very likely to lead to obstructive phenomena, due to kinking of the intestine. (3) The *suppurative* variety is characterized by the presence of tuberculous foci of some size between the coils of intestine; caseation and suppuration follow, and the abscesses are likely either to open into the intestine, possibly into two coils, causing thereby a fistulous communication (*fistula bimucosa*), or perhaps to travel to the surface and open externally, and then most frequently at the umbilicus, possibly giving rise to a fæcal fistula.

In each of these varieties acute manifestations may develop at any time as a result of infection from the bowel with the *B. coli*, and then the symptoms of acute diffuse peritonitis may supervene.

The **Symptoms** are extremely variable, and the early stages of the disease are sometimes not easy to recognise.

A few cases have an *acute* onset with abdominal pain and distension, and continued pyrexia which may suggest the existence of enteric fever. The abdominal wall, however, is not rigid; the tenderness is not great; there is well-marked evidence of free fluid, and though vomiting and constipation may be present, they are not marked features. Naturally the patient in such a condition wastes quickly.

In the more *chronic* forms the earliest symptoms are weakness with some slight abdominal discomfort, and not uncommonly diarrhœa, alternating perhaps with constipation. The temperature becomes of a hectic type, and periods of improvement may alternate with attacks of increasing pain and weakness. On the whole, the patient gradually gets worse, his wasted frame comparing markedly with the protuberant and enlarged belly. The phenomena discoverable on abdominal palpation vary considerably with the conditions present within.

Treatment in the early stages, and especially in the acute variety, is often successfully undertaken by the physician. Hygienic measures are adopted, the patient living in the fresh air, and, of course, being always in the recumbent position. Plenty of good digestible food is given, as also cod-liver oil and perhaps intestinal antiseptics, such as salol, creasote, etc. The external application to the abdomen of iodine, either as a paint or an ointment, is much commended by some physicians, whilst Scott's dressing is relied on by others. Tuberculin injections may also be of value. Should the condition undergo no improvement, it may be justifiable to operate. When chronic ascitic accumulation is present, all that is needed is to remove the fluid by tapping or laparotomy; in the latter case irrigation is not required, and the wound should be closed completely; in nearly 75 per cent. of the cases a cure may be anticipated. Possibly it may be well to ascertain first the condition of the opsonic index, and, if need be, to raise it by injections of tuberculin. In the acute forms tuberculous infection of the wound usually follows the escape of the highly infective fluid from the peritoneal cavity, and healing may be thereby delayed; hence it is undesirable to operate in such cases. Where diffuse or localized suppuration is present, adhesions which can be reached may be gently broken down, and exit given to the pus; but no prolonged search after suppurating foci should be made, or the intestine may be torn. The results of treatment in this variety are not nearly as satisfactory as in the former, at least 40 per cent. of the cases dying. As to the way in which cure is established, two factors probably co-operate: (1) the removal of the exudation and its contained toxins; and (2) a flushing of the intra-abdominal tissues with blood plasma (a well-ascertained fact after laparotomy) and the effect of the antibodies contained therein, the tubercles thereby having their vitality destroyed. In this connection one may note the statement that too early a laparotomy does but little good, an insufficient amount of antibody having presumably developed in the system.

Pneumococcal Peritonitis is in the majority of cases secondary to a similar infection of the lungs or pleura, the organisms being transmitted by the blood or through the lymphatics of the diaphragm; less frequently the primary focus is in the pharynx or middle ear. Occasionally the trouble is apparently primary, the pneumococci finding their way through a healthy mucous membrane, as from the bowel or appendix, or more directly by the Fallopian tube. The disease is specially common in female children, and usally sets in acutely. In some cases the trouble quickly becomes circumscribed, and a chronic encapsuled abscess results; in other cases the course is acute, and the symptoms are persistent and more violent. In the former, pain and vomiting are moderately severe in the early stages, but diarrhœa is often present, and pyrexia is moderate. Pus is likely to accumulate slowly, and without marked pain and discomfort; at first it occupies the lower part of the abdomen, but gradually encroaches on the whole cavity, and typical dulness may be noted, whilst the patient wastes rapidly. In some cases the pus has pointed at the umbilicus, and a spontaneous cure has followed its discharge. In the more acute cases the course is very similar to the diffuse pyococcal type described above; prostration is generally rapid, and death early; the only distinguishing feature is the existence of diarrhœa in some cases. The pus is usually like that in a pneumococcal empyema (p. 923), with abundance of false membrane, but in other cases it is of the ordinary type; pneumococci can easily be found in it. A blood count will show a well-marked leucocytosis, which is usually absent in the worst forms of pyococcal peritonitis. *Treatment* consists in laparotomy and drainage in the more acute varieties, but in the milder the patient must be carefully watched for localizing phenomena.

Gonorrhœal Peritonitis almost always occurs in women as a direct extension of a gonococcal inflammation upwards from the uterus, being preceded or accompanied by the phenomena of salpingitis or ovaritis; it has, however, been known to develop in men. There is usually a definite history of gonorrhœa with a more or less abundant discharge, but the attack generally follows a menstrual period, or the manipulation of the tubes and ovaries. The onset is sudden and acute, the patient complaining of severe pelvic pain, which is accompanied by vomiting, abdominal distension, and fever. A swelling may be felt above the brim of the pelvis. Under suitable treatment the trouble often abates rapidly, and the patient recovers; but adhesions are likely to be left, determining sterility, or the tubes may remain full of pus (pyosalpinx). In other cases exudation is abundant, though there is a tendency to limitation of the trouble, and the prognosis is generally favourable. *Treatment* consists in absolute rest, fomentations to the abdomen, hot vaginal douches, and suitable limitation of diet. If rapid improvement does not follow, a median laparotomy should be undertaken in order to let out the pus and permit of suitable drainage The tubes and ovaries should always be explored in such cases, and may perhaps need to be removed.

Subphrenic Abscess is the term applied to a suppurating focus which is in more or less intimate relation with the under surface of the diaphragm. Two main varieties are described, viz., the intraperitoneal, which is much the more common, and the retro- or extraperitoneal. The former are not unfrequently *subhepatic* as well as *subdiaphragmatic*.

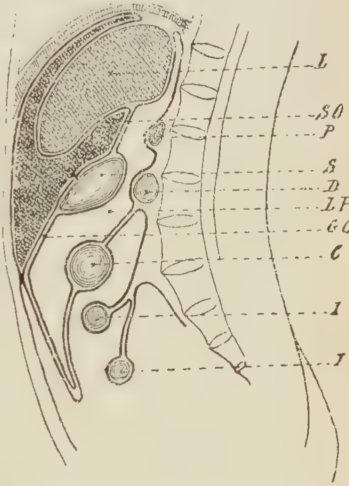


FIG. 466.—DIAGRAM OF SUBPHRENIC AND SUBHEPATIC ABSCESS, DUE TO EXTENSION FROM AN ULCER OF THE ANTERIOR WALL OF THE STOMACH.

S, Stomach; C, colon; I, small intestine; L, liver; GO, great omentum; SO, small omentum; LPS, lesser peritoneal sac; P, pancreas; D, duodenum.

The causes are very diverse, and the manifestations vary somewhat with the causative lesion. 1. The *stomach* is the most frequent source of the trouble, the infection being due to the extension of a chronic ulcer. If the *anterior wall* is involved, the pus will be limited by the lesser omentum and stomach behind, by the diaphragm and left lobe of the liver above, by the falciform ligament on the right, and by adhesions between the stomach or omentum and anterior abdominal wall below (Fig. 466). This type of abscess usually points to the left of the ensiform appendix. Should the ulcer be situated on the anterior wall near to the fundus, the abscess may get into close relationship with the spleen, and point beneath the left costal margin. When the abscess arises in relation with the *posterior wall*, the lesser sac of the peritoneum may be filled with pus, which is prevented from escaping from the foramen of Winslow by adhesions, whilst the stomach itself is pushed forwards, and the pus travels up and presents above it to the left of the middle line. More often the lesser sac has been previously obliterated, and the abscess develops in the retroperitoneal tissues. 2. Ulcer of the *duodenum* may give rise to very similar conditions. If the ulcer is in the first or second part, an intraperitoneal abscess is likely to form, bounded by the liver, colon, omentum, and anterior abdominal wall; occasionally the pus also tracks up behind the liver. When retroperitoneal suppuration occurs in connection with the duodenum, the pus travels up between the liver and diaphragm, or downwards towards the loin. 3. The *appendix vermiformis* is also a cause of subphrenic abscess, the pus burrowing behind the peritoneum, or finding its way along the inner or outer walls of the ascending colon. 4. It may be caused by extension of suppuration from the liver, colon, intestine, or from retroperitoneal structures, such as the kidney, ribs, or vertebræ. According to Fenwick, however, 80 per cent. of all cases of subphrenic abscess are due to ulceration of the stomach or duodenum.

The abscess thus induced may contain pus alone or, in addition, gas, which is derived either from a direct communication with the bowel, or from the activity of the *B. coli* without any definite opening being present. It was to this condition that Leyden originally gave the name of *subphrenic pyo-pneumothorax*. The extension of the abscess along the under surface of the diaphragm often leads to that structure being displaced considerably upwards, and to a secondary infection of the pleura, either by lymphatic absorption and extension, or by an actual solution of continuity. The effect is an effusion of serum or pus into the base of the pleural cavity, the latter constituting a basal empyema.*

The **Symptoms** vary considerably. They may be preceded by those referable to the causative lesion, and their onset may be sudden or gradual. Ordinary febrile phenomena, and perhaps one or more rigors, may occur, whilst the patient complains of pain in the upper part of the abdomen, together with vomiting and constipation. The pain is often increased on respiratory movements, and may extend upwards to the shoulder. On palpation, the abdominal muscles on one or other side are held rigidly contracted, but possibly a swelling, either dull or tympanic according to its contents, may be noted. There may be some bulging of the intercostal spaces. On the right side the diaphragm may be pushed up, and the liver downwards; and if the abscess contains gas, an area of tympanitic resonance may be noted between the dulness of the liver and the resonance of the lung. On the left side the heart may be pushed upwards together with the diaphragm, and the absence of lateral displacement of the heart is an important diagnostic feature from a pure empyema or pneumothorax. The X rays will sometimes be useful in recognising displacement upwards of the diaphragm, and immobility of the affected half. A blood count is important in indicating the existence of suppuration.

The **Treatment** consists in opening and draining the abscess wherever it is most accessible. In many cases this can be effected through the anterior abdominal wall along the lower margin of the ribs, but even then a counter-opening is often needed. When the abscess does not project anteriorly, the best situation for an opening is through the pleural cavity, as for some abscesses of the liver. The incision lies behind the mid-axillary line, a portion of the eighth or ninth rib being excised. If, as often happens, there is also an empyema, this is drained, and then an additional opening can be made through the diaphragm if one does not already exist; if, however, the pleural cavity is not affected, the serous membrane covering the upper surface of the diaphragm must be stitched to the parietal pleura before the diaphragm is incised.

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* For a complete and masterly study of subphrenic abscess, by the late Mr. Harold L. Barnard, see *British Medical Journal*, February 15 and 22, 1908.

Ascites.—By this term is meant an accumulation of fluid, and that usually of a serous type, within the peritoneal cavity. It results chiefly from lesions which fall to the care of the physician--viz., cirrhosis of the liver, chronic Bright's disease, and various cardiac affections. It is also a consequence of any obstructive pressure on the portal vein, as by malignant glands in the portal fissure secondary to carcinoma of the stomach or of the intestine, or by fibrous adhesions, the consequence of duodenal ulceration or stones in the gall-bladder. Fluid also collects in the abdomen as the result of diffuse malignant deposits scattered over the peritoneum, or from the presence of mildly irritative foci, such as hydatid cysts, etc. *Chylous* ascites is a condition in which the fluid is milky from an admixture of chyle, and usually results from rupture of the receptaculum chyli in consequence of the pressure on the thoracic duct above it of malignant glands secondary to cancer of the stomach. *Encysted* ascites results from the distension of a portion of the cavity which has been shut off by inflammatory adhesions.

The **Physical Conditions** resulting from ascites are easy of recognition. The abdomen is distended, like a barrel, but with bulging flanks. Dulness is present in the loins when the patient is recumbent, and extends forwards to about the same level all round, the only resonant area being about the umbilicus; this is due to the floating forward of the intestines. On rolling the patient over to one side, the dull and resonant areas shift, the part that is highest becoming resonant. This sign is occasionally absent if the mesentery is short or if the intestines are tied down posteriorly. On flicking the abdomen, a well-marked thrill is usually transmitted from one side to the other. Necessarily, the fluid also finds its way into any diverticula of the peritoneum, such as an unclosed funicular process or a hernial sac. The **diagnosis** of ascites should not be difficult, but the practitioner must not be satisfied until he has discovered the cause, and this may not be easy even when the fluid has been removed, so that the abdominal viscera become palpable.

Treatment necessarily varies with the cause of the accumulation. Should it persist, and the patient's breathing be hampered by the abdominal distension, removal by *paracentesis* is essential. The usual plan adopted is to seat the patient on a chair and to encircle the abdomen with a flannel binder, the ends of which are split to within 6 inches of the middle line. The unslit portion is placed over the abdominal wall in front, whilst the divided portions cross behind, and are held by assistants, so as to make continuous pressure upon the abdominal contents. The bladder is completely emptied, and then the abdomen is carefully percussed, and a spot of absolute dulness selected; here a small incision is made with a scalpel after careful purification of the skin, and a suitable trocar and cannula inserted. The median line below the umbilicus is the place usually chosen for the puncture, but there is no objection to inserting the trocar through the flanks. Some surgeons prefer to withdraw the fluid more slowly, so as to prevent the shock often experienced from its rapid removal. Two or three Southey's trocars and cannulæ may then be inserted.

Not unfrequently the fluid re-accumulates, and the process has to be repeated after a time. When the cause of the collection is doubtful, the practitioner will take the opportunity offered by the lax abdominal wall to palpate the viscera; light may also be thrown on an obscure case by a cytological examination of the fluid. In malignant disease, cancer cells and blood may often be found. If the cause is still uncertain, an exploratory laparotomy may be advisable.

In cases due to hepatic cirrhosis, **Epiplopexy** (the Talma-Morison operation) may possibly be of some use. The object is to relieve the obstruction to the portal system by opening up fresh communications between it and the systemic veins. The method consists in fixing the great omentum to the abdominal wall and determining the formation of adhesions; necessarily the peritoneum has to be drained and kept dry during this procedure, and the question arises as to whether this drainage is not the cause of the improvement. The mortality is not inconsiderable, especially when the liver is small; the best results have been gained with hypertrophic cirrhosis. The method is still on its trial, but appears to be justifiable in suitable cases.

Affections of the Great Omentum.

The omentum is of great surgical importance in the abdomen, in that it covers in and protects the viscera, and by its mobility is able to apply itself to many a weak spot where perforation or infection might occur, and thereby guard the patient from serious inflammatory mischief. The result of this process is, however, the formation of adhesions which by the irritation of constant movement may stretch and become rounded and cord-like, and various forms of intestinal obstruction (by strangulation, kinking, etc.) may result therefrom. The value of this protective power of the omentum is recognised by surgeons in the employment of *omental grafts* to add security to a line of junction in the intestinal wall with which they are not quite satisfied. It is only occasionally that such a provision is required. The best method to adopt is to detach the graft entirely from its former connections, wrap it round the gut, and stitch it in place.

The omentum may be torn, and holes may be formed in it as a result of **injury.** The immediate symptoms would be pain, shock, and the phenomena of intraperitoneal hæmorrhage; but it is likely that other injuries co-exist. At a later date the hole might be the site of an attack of internal strangulation.

Acute Inflammation (epiploitis) has been lighted up as a result of the application to the omentum in a hernia operation of a septic ligature. The phenomena vary with the virulence of the organisms, an acute diffuse peritonitis perhaps resulting. In the milder forms a localized inflammatory disturbance follows, with all the phenomena of a limited peritonitis; suppuration may ensue, and a large intraperitoneal collection of pus may result.

Torsion of the omentum is an occasional complication of an irreducible hernia, and that usually on the right side. The lesion generally follows some heavy strain, and results in venous stasis, effusion of a blood-stained fluid, the formation of extensive adhesions, and possibly gangrene and general peritonitis, if left long enough. The symptoms often start abruptly with colicky pain in the right iliac fossa and scrotum, together with constipation and sickness; the hernial swelling becomes enlarged, and extending upwards from the iliac region a sensitive mass may be detected on palpation, which is dull on percussion, and sometimes reaches to the epigastrium. The temperature is normal, though the pulse-rate is accelerated. Treatment is obviously operative, and consists in removal of the omentum.

Chronic peritonitis, whether simple or tuberculous, may cause the omentum to be rolled up into a more or less solid mass, which lies transversely across the abdomen a little above the umbilicus. There is usually a band of clear resonance between it and the hepatic dulness, which is of great diagnostic importance.

The omentum also becomes infiltrated with secondary cancerous nodules, which can sometimes be palpated, and their presence gives important indications as to the desirability or not of operative treatment. Colloid degeneration is not uncommon in omental cancers, and huge masses of this growth have been sometimes discovered in the dead-house. Omental carcinoma usually leads to a considerable effusion of fluid into the peritoneal sac.

Affections of the Mesentery.

Wounds result from penetrating or non-penetrating injuries. They are usually associated with laceration of the intestine, and the resulting phenomena will be those of hæmorrhage, followed by general peritonitis from the intestinal lesion. Pure mesenteric wounds not involving the bowel are generally due to penetrating or gunshot injuries. Hæmorrhage to a varying degree may result, and if the patient lives, the nutrition of the intestine may be seriously endangered. If such a lesion is found on exploration, bleeding points must be secured and the opening in the mesentery closed; before this is accomplished, however, careful consideration must be given to the vascular supply of the intestine, as the ligature of a main branch of a mesenteric artery may determine gangrene, and necessitate resection of a portion of the bowel.

Thrombosis of the Mesenteric Vessels, apart from strangulation or volvulus, is usually the result of embolic obstruction of the artery, but may sometimes commence in the veins, spreading down from the liver, or originating in some intestinal ulcer. The process is associated with acute pain, and is followed by the symptoms of acute obstruction. The bowel becomes engorged with venous blood, and dies; it is often occupied by a blood-stained effusion, and the passage of dark tarry stools may be noted. The peritoneal cavity contains a quantity of blood-stained serum, which after a time becomes offensive. A diagnosis is rarely reached apart from operation for the obstructive phenomena, and the only hope for the patient is removal of the gangrenous bowel (if that be possible), and a temporary enterostomy. Should the patient live, a very doubtful contingency, the continuity of the gut may be subsequently restored.

The **Mesenteric Glands** frequently become inflamed in consequence of some intestinal lesion—*e.g.*, typhoid ulceration. No special notice is taken of this occurrence, unless suppuration ensues, when the abscess must be opened. In less severe cases, however, it is often associated with a patch of localized peritonitis, resulting in the deposit of plastic lymph; to this some other viscus—*e.g.*, the free end of the omentum, the fimbriated extremity of the Fallopian tube, the vermiform appendix, one of the appendices epiploicæ, etc.—may become adherent, and an adhesion may develop which subsequently leads to intestinal obstruction. As a matter of fact, the great majority of intra-abdominal bands are connected at one end with the mesentery.

Tuberculous Disease of the mesenteric glands is a common affection in children, constituting a condition known as *tabes mesenterica*. It is probably secondary to intestinal lesions, and when widely diffused through the mesentery is, of course, to be dealt with only by hygienic and medical measures. The results of such treatment are frequently very satisfactory, but tuberculous peritonitis may follow. Sometimes the glands undergo calcification, and these may lead to a mistaken diagnosis if a patient is examined radiographically for supposed ureteral calculus. At other times the caseated glands may liquefy and give rise to an inflammatory attack that may be mistaken for appendicitis, if the mesentery of the lower end of the ileum is involved. Limited masses in the iliac fossa may sometimes be amenable to surgical measures, and be removed; whilst occasionally the surgeon has to deal with a gland which has suppurated, and requires to be opened with the same precautions as one would take in dealing with an appendix abscess. Adhesions also form between the glands and surrounding parts, and intestinal obstruction may result.

Cysts of the mesentery are not common, and, as might be expected, they are usually of lymphatic origin; they may be single, containing either lymph or chyle, or multiple, then constituting a cavernous lymphangioma. Blood cysts have also been known, and also dermoids, which are usually located in the mesentery of the ileum. A rounded, tense intra-abdominal swelling gradually develops behind or below the umbilicus; it is freely moveable from side to side, and is usually accompanied by some derangement of intestinal movement or function. When of large size, the swelling is dull, but is often crossed by the affected loop of bowel; it may possibly be mistaken either for an ovarian or a pancreatic cyst. The diagnosis is usually made on the operating-table, and the treatment consists in enucleation or drainage, with or without removal of the affected coil of intestine.

Tumours form occasionally in the root of the mesentery and behind it, constituting the retroperitoneal lipoma or sarcoma. The former may grow to a large size, and destroy life by its pressure phenomena; the latter, though sometimes resembling the former in structure, invades surrounding tissues earlier. The diagnosis is uncertain until the abdomen is opened, and the question of removal is dependent on the relation of the growth to the mesenteric vessels, which must not be injured. It is seldom that a retroperitoneal sarcoma can be enucleated.

Affections of the Stomach.

The cardiac orifice lies about 4 inches behind the junction of the seventh costal cartilage with the sternum; the highest part of the fundus reaches the fifth left rib in the mammary line; the pylorus when the stomach is empty is in the middle line midway between the suprasternal notch and the symphysis pubis (Addison's transpyloric plane). When the stomach is full, the pylorus passes more or less to the right of the middle line and descends slightly. The lower border can usually be defined with tolerable accuracy by auscultatory percussion; this is performed by applying a stethoscope over the centre of the stomach area and percussing outwards over the margin; a change in note is readily recognised on reaching the border of the stomach.

When pathologically dilated, the stomach becomes enlarged downwards, the pylorus and lesser curvature being retained more or less in position by the gastro-hepatic omentum, so that the organ pouches down towards the pelvis and becomes an elongated sac in which fluids accumulate and decompose and gas collects. Peristaltic waves can often be seen crossing the viscus, and on succussion or tapping the organ with the finger-tips, gurgling and splashing sounds are heard. The stomach can be inflated and its exact size and shape thereby determined more accurately either by passing an œsophageal tube and injecting air with a bicycle pump, or by the administration of effervescent solutions, such as tartaric acid and bicarbonate of soda (10 to 20 grs. of each), or of the component parts of a Seidlitz-powder separately dissolved in water.

Radiography has also proved of service in demonstrating the activity and shape of the stomach after the administration of a bismuth meal, which consists of a mixture of 1 or 2 ounces of bismuth oxychloride in gruel or bread and milk X-ray photographs or screen examinations are then made at intervals so that the changes in shape of the stomach as indicated by the shadow cast by the bismuth can be ascertained (Figs. 467 to 470). The greater curvature of the stomach should reach to a little below the level of the umbilicus (this owing to the weight of the bismuth meal), and the viscus should empty itself in about four hours. Direct visual examination of the gastric cavity is also possible (gastroscopy).

Much may be learnt of the functions of the stomach by a careful examination of its contents and secretions. This is best accomplished by administering a **test meal** consisting of a piece of toast, or a rusk and a cup of tea without milk, on a fasting stomach. This is withdrawn in one or one and a half hours by a stomach pump or œsophageal tube, and the fluid thus obtained is examined as follows:

(*a*) Chemically—to ascertain the amount of total acidity, the amount of free hydrochloric acid, and the presence or not of lactic acid.

(*b*) Microscopically—for the presence of yeasts, sarcinæ, or bacteria, especially the long non-motile Oppler-Boas bacilli; shreads of tumour, pus cells, or blood, may also be found. The healthy stomach is practically free from organisms, as those swallowed with the food soon disappear. Not unfrequently, however, they are found in the empty stomach of those suffering from pyorrhœa alveolaris, and are then likely to be of the same character as those around the teeth.

The following are suggestive samples of the results obtained by test meals:

1. In the *normal stomach* the amount of fluid withdrawn is about 2 to 4 ounces. It contains no undigested food. Free hydrochloric acid is about 1·5 to 2·0 per cent. No lactic acid or organisms are found.

2. In *gastric ulcer* the amount withdrawn is normal in quantity or decreased. Digestion is complete. Free hydrochloric acid is increased (hyperchlorhydria)—2·5 to 3·0 per cent. No lactic acid, organisms, or growth found. Blood may be present.

3. In *atony of the stomach* the amount withdrawn is increased (6 to 8 ounces) and digestion is imperfect. Free hydrochloric acid is decreased or absent (hypochlorhydria)—0·5, 1·0, or 0·0 per cent. Traces of lactic or butyric acid present. Yeasts and sarcinæ present.

4. In *carcinoma of the fundus* the amount withdrawn is normal or increased 3 to 5 ounces. Hydrochloric acid is absent, but lactic acid exists (0·2 to 0·5 per cent.). Oppler-Boas bacilli may be present, and fragments of growth or blood may be found.

Rupture of the Stomach results from blows or falls upon the epigastrium, especially after a heavy meal, and then usually involves the pyloric end or the greater curvature near the cardiac orifice. It may also follow a penetrating injury, such as a stab or a fall upon a spike or railings. Neighbouring viscera are not unfrequently involved in the lesion, especially the liver or spleen.

The **Symptoms** are those of severe and prolonged shock, with epigastric pain and vomiting, the ejected material sometimes containing blood; acute septic peritonitis usually ensues in a very short time, causing rapid collapse and death. Occasionally, when the wound is small, or the organ empty at the time of the accident, there is little or no extravasation, and then a localized intraperitoneal abscess may form, shut off from the general peritoneal cavity by adhesions, and sooner or later bursting and discharging into the stomach, colon, or one of the hollow viscera, or else coming to the surface and bursting externally; sometimes the barrier of adhesions gives way, and a late general peritonitis results. If the posterior wall of the stomach is alone injured, the resulting phenomena are very similar to those due to the perforation of an ulcer in this region (*q.v.*).

Treatment.—No time must be lost in undertaking a laparotomy when the diagnosis is tolerably certain, since the only hope of saving the patient's life lies in early interference. A median incision is made above the umbilicus, the situation of the injury in the stomach ascertained, and the aperture closed by a double row of sutures (Czerny-Lembert), which infold the margins, and extend a little beyond the lesion at either end (Figs. 458 and 460). All extravasated material should be carefully sponged or swabbed away, and if the general cavity has not yet become inflamed, irrigation should be avoided for fear of carrying infective material to other regions. If the posterior wall is also injured, as by a bullet wound, an opening

RADIOGRAMS OF THE STOMACH AFTER BISMUTH MEALS.

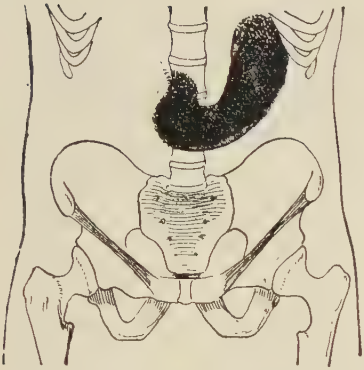

FIG. 467.—NORMAL STOMACH.

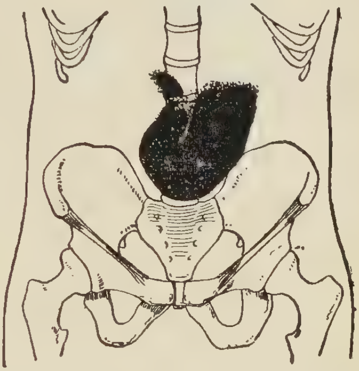

FIG. 468.—MODERATE GASTROPTOSIS.

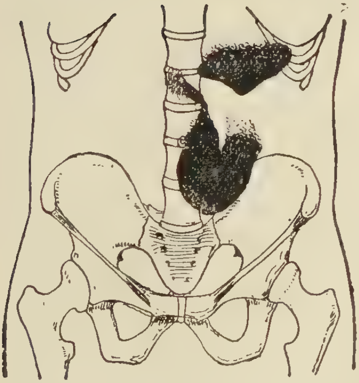

FIG. 469.—HOUR-GLASS CONTRACTION OF STOMACH

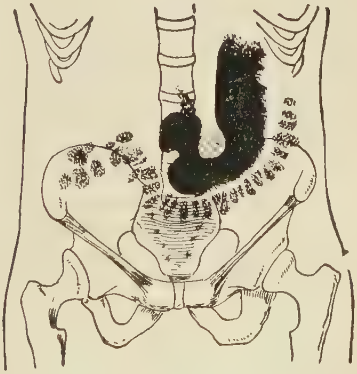

FIG. 470.—CANCER OF STOMACH.

The excavation of the upper border of the shadow marks the site of the cancer.

should be made through the omentum so as to explore and cleanse the lesser sac of the peritoneum. If the case has been operated on early and there is but little peritoneal inflammation, it may be possible to close the parietal wound entirely; but, as a rule, it is necessary to insert a gauze drain in the upper part of the serous cavity. If the general cavity is inflamed, the treatment suitable to acute peritonitis must be instituted (p. 976).

Foreign Bodies in the stomach consist either of those which have been swallowed accidentally or intentionally, or of concretions, *e.g.*, hairs, wool, etc., due to the constant ingestion of small portions, which remain in the viscus and may after a time form large masses. The presence of the former is known from the history, whilst the latter may give rise to symptoms of gastric irritation, the cause of which is inexplicable until the mass has attained such a size as to suggest the presence of a tumour. The only treatment possible for a foreign body of any size is to open the organ and remove it (gastrotomy); where, however, it is of small dimensions, *e.g.*, a coin, it may be allowed to pass onwards.

Acute Phlegmonous Gastritis is an affection due to bacterial invasion of the submucous coat of the stomach, which is infiltrated with leucocytes and fibrinous exudation, together with many organisms, especially streptococci. This process usually ends in suppuration, which may manifest itself as a diffuse purulent infiltration, or as a more or less localized abscess; or the whole mucous lining of the stomach may be cast off as a slough and vomited. Such a condition, if not fatal from exhaustion, toxæmia, or general peritonitis, will be followed by extensive stenosis, which may demand operative treatment. The disease usually occurs in men who suffer from chronic dyspepsia, and is lighted up by injudicious dietary, excess of alcohol, or possibly the taking of corrosive poisons. It may develop as a secondary result of ulceration or of operation. The symptoms consist of epigastric pain, persistent vomiting, and marked restlessness, going on to delirium or collapse; the pulse is quickened, and there is moderate fever. The diagnosis is usually uncertain, and treatment is consequently merely symptomatic. Lavage of the viscus will be of some use.

Ulcer of the Stomach is an exceedingly common ailment, the consequences of which are often very serious, a considerable mortality being associated with it, its complications, or its sequelæ. Two chief types may be mentioned here, although others are not unknown.

(*a*) The **acute** ulcer is rarely larger than a sixpenny-piece, and 'develops with almost equal frequency at any spot between the cardia and the pylorus along the upper margin of the stomach, and more frequently on the posterior than on the anterior surface' (Fenwick). It is not unusually multiple, two ulcers being often found exactly opposite one another, suggesting an infective origin of the trouble. They are circular in shape, and with the edges sharply defined and clearly cut; each successive coat is destroyed to a lesser degree than the one internal to it, so that the sore is truncated or funnel-shaped. Should perforation occur, the opening is not central, but slightly to one side. These acute ulcers heal without much difficulty, as is evident from the number of radiating cicatrices seen on the post-mortem table. They give rise to no stenosis, except perhaps when they are actually situated within the pyloric orifice. Hæmorrhage from this variety is not uncommon, but rarely fatal.*

(*b*) The **chronic** ulcer may attain considerable dimensions, perhaps many square inches of each surface being involved. It is usually single, and situated on the posterior wall near the pyloric orifice, which may be involved in the trouble by extension. Its shape is very variable, though in the earlier stages it is rounded; one important type is the horseshoe ulcer, which spreads down along either surface from the lesser curvature, and may subsequently cause an hour-glass contraction of the organ. The edges are often raised, hard, and infiltrated, whilst the gastric wall is generally thick and sclerosed. In old-standing cases there may be considerable destruction of tissue, surrounding viscera, such as the pancreas, being sometimes exposed thereby. Hæmorrhage is not uncommon, and may prove fatal; one of the larger branches of the coronary artery, or perhaps the splenic, is then involved, or the bleeding may arise from one of the enlarged varicose gastric veins which are often found in the neighbourhood of an old ulcer. Perigastric inflammation of an adhesive or suppurative type is almost certain to occur, and cicatricial contraction of various forms is likely to follow.

Women are much more liable to gastric ulcer than men, in the proportion of three to one; but it is the acute variety to which they are most prone, and from which, apart from perforation, they seldom die. The usual age of such patients is from fifteen to thirty years. Men, on the other hand, are more liable to chronic ulcers, and though acute perforation is less common, they are subject to a number of serious complications which may prove fatal. Their average age when attacked is from thirty to fifty years.

Into the ætiology, general symptoms, and routine treatment of gastric ulcers it is unnecessary to enter; they are sufficiently described in medical text-books. A number of complications, however, arise which may require surgical assistance, whilst it must be remembered that the mere persistence of symptoms may justify operative measures, especially since the observation has been made and confirmed that malignant disease may commence on the site of an old-standing ulcer.

1. **Excessive and Persistent Hæmorrhage** is responsible for a considerable proportion of the deaths from gastric ulcer. It may arise from arteries, veins, or capillaries. In the superficial ulcers of young people the bleeding is usually of capillary origin, or at worst is derived from some small arteriole. In the more chronic ulcers

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* See Fenwick, 'Ulcer of the Stomach and Duodenum,' J. and A. Churchill, 1900; and Mayo Robson and Moynihan, 'Diseases of the Stomach and their Surgical Treatment,' Baillière, Tindall and Cox.

deeper and larger vessels may be laid open, and it is in such instances that a fatal result may follow; thus the splenic or coronary artery may be involved, and hopeless hæmorrhage ensue. Occasionally bleeding occurs as a generalized gastrorrhagia, where, on opening the stomach, the whole surface seems to weep blood; this condition is but little understood. It is uncommon for the patient to succumb to the first attack of bleeding, which yields to medical treatment, and hence the rule of practice which is usually adopted, viz., to treat the first acute hæmorrhage by medical means; but should it recur or persist unduly, surgical assistance may be required.

If the bleeding is small in amount, but recurs constantly, gastro-enterostomy should be undertaken, in order to put the organ at rest and allow the ulcer to heal. When, however, the hæmorrhage is more severe, a determined attempt must be made to find the bleeding spot and deal with it. The abdomen is opened and the stomach carefully explored. Some puckering or thickening of the coats may indicate the situation of the ulcer; failing this, a free opening in the longitudinal axis is made through the anterior wall, and the interior of the viscus methodically examined. When the bleeding point has been found, it may be possible to pick it up and tie it; or the whole ulcer may be picked up and ligatured *en masse ;* or the base of the ulcer may be cauterized; or excision of the ulcer may be practicable. Failing these measures, gastro-enterostomy will be indicated, and the result is usually satisfactory.

2. **Perforation** is by no means an uncommon occurrence, and unless recognised and treated early is fraught with the greatest danger. The anterior wall is more frequently involved than the posterior (7 to 1), owing to its greater mobility, which prevents the formation of protective adhesions. The cardiac end is more often affected in young people, but the majority of perforations are to be found near the pylorus and towards the lesser curvature in middle-aged people with chronic ulcers. In 20 per cent. of the cases two perforations are stated to be present (Moynihan), but this is very doubtful. The character of the perforation varies considerably; it may be small as a pin-prick, or as large as a threepenny piece. The margins may be œdematous and inflamed, or in cases associated with chronic ulcers may be thick and cicatricial in character, with no tendency to close spontaneously. The symptoms necessarily vary with the size of the perforation, and with the distension or not of the viscus. If a large opening is produced in the anterior wall, so that the gastric contents are allowed a free entrance into the peritoneal cavity, the patient is seized with severe epigastric pain and profound shock, and this is followed by acute diffuse peritonitis, which rapidly proves fatal if surgical interference is not at hand. When the perforation is small and the stomach empty, the initial symptoms of pain and shock may quiet down in twenty-four hours, and the patient recover spontaneously; the opening is then closed by lymph or the omentum. Sometimes, however, a gradual leakage occurs; the onset is then subacute; the primary shock is often inconsiderable,

but epigastric pain and tenderness are present, together with marked rigidity of the abdominal wall; a short period of improvement follows the primary shock, and then the symptoms steadily increase until the characteristic features of general peritonitis supervene.

The **Prognosis** of gastric perforation is exceedingly grave, since, unless active surgical interference is obtainable within a comparatively short time, hopeless peritonitis ensues. Statistics indicate that 95 per cent. of untreated patients die, whilst the later the operation, the worse the results. If operation is undertaken within six hours, recovery is usual; if within twelve hours, it is not unusual; but later than that it is most uncertain.

Treatment.—Should it be decided for any particular reason not to operate in a given case, the horizontal position, rectal feeding, and the use of morphia to check peristalsis, are the only means which hold out any prospect of benefit. Operation, as already indicated, must be undertaken at as early a period as possible, although it is often wise to delay for an hour or two to allow the patient to recover in measure from the initial shock. The median incision is the best to employ, since it is not possible to be certain as to the situation of the lesion. The rules given above as to the treatment of a penetrating injury hold good in connection with this subject, especially as to the use of swabs for the removal of any extravasated gastric contents, and as to the value of peritoneal irrigation. There is no need to excise the ulcer when found; all that is required is to close the aperture by means of Lembert's sutures, which infold and bury the perforation; this is sometimes a matter of some difficulty when the margins are thick and sclerosed. In a few cases it may seem unwise to attempt closure of the lesion, whilst in others it may be so situated as to render such closure impossible; a drainage-tube, free from lateral openings, is then introduced into the stomach, and gauze packed around it so as to lessen the risk of intraperitoneal leakage. The patient is fed by the rectum for some time, and the fistula usually closes without much difficulty at a subsequent date.

The operation should always include an examination of the lesser sac, which may have been infected through the foramen of Winslow or by a second perforation. This is the more necessary when the clinical symptoms point to a serious lesion, and nothing is found in the main peritoneal cavity to explain them; under such circumstances, if the lesser sac is also free from inflammation, the vermiform appendix should be examined, as it is often responsible for many atypical conditions. Another point may also require consideration before closing the abdominal wound, viz., whether or not it may be desirable to undertake a gastro-enterostomy at once. If the opening involves the pyloric region so as to threaten subsequent stenosis, and if the condition of the patient is sufficiently good, the anastomosis should always be performed. If left till a later date, it may be rendered extremely difficult or almost impossible by the development of adhesions.

After-treatment is as for all cases of diffuse septic peritonitis (p. 976).

The patient is placed as soon as possible in the sitting position. Mouth-feeding is of course forbidden for two or three days, and rectal alimentation relied on. Turpentine enemata are employed to relieve distension and empty the bowel.

3. **Perigastric Inflammation** is a common result of ulceration; it may be either adhesive or suppurative in character.

Adhesive Perigastritis is in the first place protective in nature, consisting of a localized thickening of the serous wall. It is more marked in connection with chronic than with acute ulcers. The posterior gastric wall is often adherent across the lesser sac of the peritoneum to the serous membrane lying in front of the pancreas, and this fixity may be one of the factors which prevent the ulcer from healing, even as fixation to the periosteum over the tibia delays healing in an ulcer of the leg.

In a few cases adhesions form between the anterior wall of the stomach and the parietal peritoneum, and these may give rise to a localized fixed epigastric pain, usually increased considerably by distension of the organ. It can sometimes be treated by abdominal section and division of the adhesion between ligatures. If left alone, not only may it cause inconvenience by the pain induced, but it may also determine internal strangulation or obstruction.

Suppurative Perigastritis may follow a small perforation with limited leakage, but is more usually due to an extension of the ulcer and an invasion of the perigastric tissues by organisms which escape from the stomach. The result of this is the formation of what has been already described as a subphrenic abscess (p. 989), which may or may not contain gas. It may burst anteriorly through the abdominal wall, or may perforate the diaphragm, giving rise to a basal empyema; and this in turn may burst into the lung or through the chest wall, so that fistulæ may appear in various places, through which the contents of the stomach may be discharged.

The abscess should be opened and drained in the way already indicated, but should a fistula form, it is almost hopeless to attempt to deal with it locally, and a gastro-enterostomy may then be required.

4. **Stenosis** is always liable to follow the cicatrization of ulcers of the stomach. In the small acute ulcer the contraction rarely leads to more than a puckering of the organ; but in the chronic ulcers of large size the organ may be much altered in shape, and definite stenosis may arise. If the contraction is in or near the cardiac orifice, symptoms akin to œsophageal stenosis may be produced, the patient returning his food shortly after swallowing it. If the pylorus is affected, the stomach is often much dilated, and vomiting of a special type ensues (see Simple Stenosis of the Pylorus, p. 1002). It is important to note that muscular spasm plays a considerable part in the production of these symptoms when due to ulcer; the spasm is probably induced by the hyper-acidity of the gastric juice (hyperchlorhydria) which is often present.

The most exaggerated forms of gastric stenosis follow the cicatrization of a horse-shoe ulcer, and this constitutes the most common cause of an **hour-glass stomach**; adhesive perigastritis and cancer are also occasional causes. The constriction is usually situated about 4 inches from the pylorus, and may be so narrow as almost to divide the organ into two halves. Generally the great convexity is drawn up towards the lesser, and thereby two pouches are formed which sag downwards; in them food collects and undergoes decomposition. Vomiting more or less of a pyloric type ensues from the distension of the cardiac pouch, which is usually much the larger. On washing out the organ with a measured quantity of water, a smaller quantity often returns, some being retained in the lesser sac. On palpation this latter may occasion a succussion splash, even when the organ is apparently empty. On again passing the tube after a short interval, offensive fluid may return, especially if the pyloric pouch has been palpated. Distension of the viscus causes a definite bulging on the left side of the epigastrium in the first place; subsequently this may diminish, and the pyloric pouch become evident on the right side. Sometimes both pouches can be distinctly felt, or even seen, as well as the sulcus between them. Radiography after a bismuth meal will often demonstrate satisfactorily the existence of this condition (Fig. 469). No **treatment** is of any avail which does not provide for the drainage of both pouches and the efficient emptying of the whole organ. A few cases may be treated by excision of the stricture, or by its longitudinal division and suture transversely by a method similar to that employed for the pylorus (see Pyloroplasty, p. 1008). In the great majority of cases treatment is best effected by a double gastro-enterostomy (Fig. 471), which gives a direct communication between each segment and the jejunum.

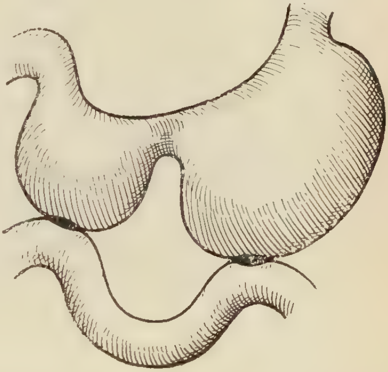

FIG. 471.—TREATMENT OF HOUR-GLASS STOMACH BY DOUBLE GASTRO-ENTEROSTOMY.

5. Finally, cases are met with in which the symptoms of gastric ulcer persist or recur in spite of the most careful dieting and treatment, and it is now considered quite justifiable to submit such cases to operation. Two lines of treatment are possible. (*a*) The ulcer may be excised, if it be in a convenient position for such a procedure, and if the infiltration around it is not too extensive. This is the more desirable, since many cases apparently benign are really malignant, and the cicatrices of such conditions, even if benign, are likely to become malignant. This practice is, however, seldom possible. (*b*) In most cases gastro-enterostomy (p. 1008) should be

undertaken in order to relieve symptoms by enabling the viscus more rapidly to empty itself after the ingestion of food, so that the ulcer may be given a better opportunity of healing. In some cases excellent results follow such a measure, but not in all.

It must be remembered that gastro-enterostomy is not a magic charm which at once and for ever cures all the troubles arising from gastric ulceration. The ulcer is still present when the operation is completed, and if chronic may take a long time to heal, and require a continuance of the dietetic and medical treatment that preceded the operation, such as the limitation of the dietary to soft articles, and only a very gradual increase in the list of things permitted, and the use of drugs, such as an alkaline bismuth mixture to neutralize the hyperchlorhydria usually present. The teeth must also be carefully attended to. Sometimes the symptoms result from an atonic gastritis with absence of HCl, and then operation will do no good. In fact, it is probable that unless some degree of obstruction is present to the onward passage of food through the pylorus and duodenum, gastro-enterostomy does but little good. It is quite clear that, unless the practitioner selects his cases for operation with great care, he will often be disappointed with the results, which do not by any means always conform to the *couleur-de-rose* picture of some writers.

Recurrence of Symptoms after Gastro-enterostomy may be due to many causes: (i.) The ulcer may have broken down again, as a result of careless or unsuitable diet, or of a general loss of health and tone. A servant girl going back to her old work and habits is very liable to this. (ii.) Adhesions between the ulcerated stomach and surrounding parts may have been stretched as the result of some traumatic influence. (iii.) Adhesions due to the operation itself may be present and give rise to trouble. (iv.) The opening into the jejunum may have contracted, and difficulty in the onward passage of the food may again be present. (v.) A peptic ulcer may have developed in the efferent loop of the jejunum (p. 1012). The history and character of the symptoms should suffice to guide the practitioner to a correct diagnosis.

Treatment.—The patient should be put to bed and treated on medical lines for a while; this will suffice in most instances to give relief. Should it fail and symptoms persist, it may be necessary to open the abdomen again and explore the parts involved. Adhesions may be divided, and if it seems likely that the opening has contracted, it may be enlarged, or a fresh anastomosis may be performed.

Cancer of the Stomach.—The stomach is more frequently invaded by cancer than any other organ in the body in the male sex, whilst in females it comes next to the breast and uterus in order of frequency. Any and every part of the viscus may be affected, but in 60 per cent. of the cases the tumour starts in or about the pylorus. It may be of a spheroidal- or columnar-celled type, but is often sufficiently hard to warrant the use of the term 'scirrhous' which is usually applied to it. When the cardiac end is attacked, the disease may spread from the œsophagus and is a squamous epithelioma; but when the body of the organ is invaded, the condition is generally a columnar carcinoma.

Cancer frequently starts at the site of an old ulcer, but often there is no assignable cause for its onset, except an indefinite history of injury. It may occur as a nodular outgrowth, perhaps covered with papillomatous projections and early undergoing ulceration; if it is of a hard type, the ulcerated surface has a characteristic everted margin. Sometimes the whole organ becomes infiltrated by a diffuse carcinomatous growth, constituting a firm mass incapable of dilatation or much contraction, which has been aptly termed the 'leather-bottle stomach.' At the pyloric end (Fig. 472) the growth is always of a hard nature, and forms an annular constriction through which it may be difficult to pass even a small catheter; it is sharply limited on its duodenal aspect, but spreads into the body of the organ, and especially towards the lesser curvature, following the main line of the lymphatic stream. The lymphatic glands lying along the lesser curvature are involved, usually extending as far as the point where the coronary artery reaches the stomach, whilst those along the pyloric end of the great curvature are implicated to a less degree (Fig. 476). Thence the affection spreads to the liver and to the cœliac glands, and may there compress the inferior vena cava and thoracic duct. Adhesions form around the growth, but are relatively later in appearance than in a single ulcer; they may fix the tumour to the under surface of the liver, to the head of the pancreas, the colon, and even when of large size to the anterior abdominal wall. These adhesions often prepare the way for an

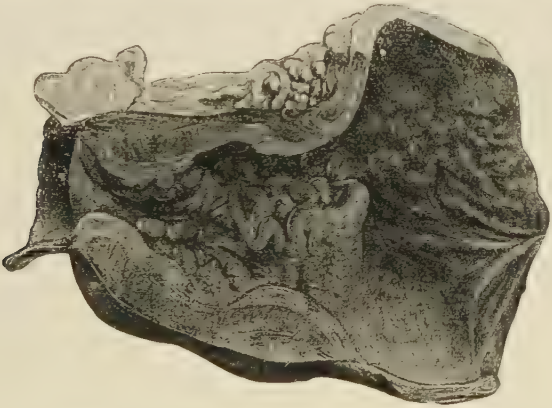

FIG. 472.—CANCER OF PYLORIC END OF STOMACH. (KING'S COLLEGE HOSPITAL MUSEUM.)

The abrupt limitation of the growth at the commencement of the duodenum is well seen.

extension of the disease to the peritoneum, over which disseminated nodules of cancer may be scattered, giving rise to a considerable effusion of serous fluid. The omentum also becomes infiltrated, and colloid degeneration is not unusual in this region, the omentum being converted into a solid translucent mass, looking sometimes like firm sago pudding.

Speaking generally, the malignancy of gastric carcinoma is decidedly less than that of such organs as the breast or uterus, in that secondary glandular affections are later in developing, and even when the nearest group is involved it may be some time before the affection spreads to distant parts.

Clinical Phenomena.—Gastric cancer begins with certain indefinite symptoms, the significance of which is easily overlooked in the early stages, so that a thorough and exhaustive examination is not made, and the time for radical interference passes without the disease being recognised. Pain is generally the earliest symptom, slight at first, but gradually increasing, and referred to the epigastrium or back. Food may increase or relieve it, but as time progresses the pain comes on independently of meals. Acid eructations and a sense of epigastric oppression soon follow, and these in time give place to actual attacks of vomiting, the ejecta perhaps containing blood, but usually not till late in the case, and as a rule not in great quantity. Loss of appetite and steady wasting are also marked features in the early stages, but the patient usually has a clean tongue. The persistence of such a group of symptoms should always determine a complete investigation of the stomach and its functions. (i.) The epigastric region is carefully palpated, and the nature and position of any unusual swelling noted. It may be desirable to inflate the organ with air or gas and ascertain its exact size; by this means it is sometimes possible to detect a tumour which would otherwise escape notice. (ii.) The composition of the gastric juice is investigated by the use of a test meal (p. 989). In cancer the amount of HCl is usually diminished, whilst that of lactic acid is increased; the latter is probably a fermentation product. This test must be looked on as a valuable, but not as a constant, indication of the presence of cancer. HCl is generally increased, and not diminished, in the cancer that supervenes on a chronic ulcer. Moreover, HCl is absent in many gastric lesions other than cancer, and hence the results of this investigation must always be considered in conjunction with the clinical symptoms. (iii.) The motor power of the viscus is very considerably lessened, so that the passage of its contents into the duodenum is delayed; this is due to a chronic interstitial gastritis. (iv.) A blood count in carcinoma usually reveals a well-marked secondary anæmia, together with a moderate leucocytosis (p. 67). (v.) Microscopic examination of the vomit may also throw light on the case by the discovery of fragments of the growth. (vi.) Radiographic examination after a bismuth meal may reveal a decided excavation of the normal shadow cast by the bismuth whilst still in the stomach (Fig. 470).

To these general signs certain special ones may be added, varying with the location of the growth. 1. If the *cardiac end* is involved, a tumour can rarely be detected, the stomach being small and contracted. The patient complains chiefly of pain on swallowing, and the vomiting occurs immediately after each meal. The symptoms are practically those of œsophageal cancer.

2. When the *pylorus* is affected, a tumour can often be felt a little above and to the right of the umbilicus, which is at first rounded and nodular; it is moveable in the early stages, but later on becomes fixed by adhesions; it is firm in consistence, and somewhat tender on manipulation and pressure, and may receive pulsation from the underlying aorta. Owing to the stenosis of the pylorus, which almost invariably accompanies this condition, the stomach becomes dilated, and its great curvature displaced downwards, perhaps almost into the pelvis. In this a large accumulation of fluid takes place, which can be heard splashing about when the patient is moved; every day or two he brings up a large quantity of fluid and decomposing food, covered with a yeast-like scum, and sometimes containing sarcinæ in abundance. Hæmatemesis is not uncommon.

3. When the *body* of the organ is involved, a tumour may or may not be felt, according to its situation. In these cases the amount of pain and vomiting depends on the degree of ulceration of the growth, and is sometimes comparatively slight, especially if the exit to the organ through the pylorus is not obstructed. It is quite possible that the tumour may have attained considerable proportions before it is discovered. The 'leather-bottle' stomach can be sometimes detected as a solid mass emerging from under the left costal margin. The organ is not dilated, and the vomiting has no special characters; hæmatemesis is usually absent, but the dyspeptic phenomena are pronounced

In the latter stages pressure phenomena manifest themselves. Ascites may result from compression of the portal vein; jaundice, from implication of the common bile-duct; œdema of the legs and varix of the superficial abdominal veins may arise from pressure upon the inferior vena cava, whilst the peritoneal cavity may be distended with chyle owing to the pressure of lymphatic glands on the receptaculum chyli or thoracic duct. All these later signs are indications that the time has passed when radical treatment is possible. A similar indication is given by enlargement of a gland in the left supraclavicular fossa, which sometimes occurs; this results from dissemination of cancer cells up the thoracic duct.

Treatment.—When the symptoms of chronic gastritis persist in spite of careful dieting and treatment, and the patient is losing flesh, one should always look on the case with suspicion. Granted that the examination of the gastric juice reveals the characteristic changes referred to above, and still more when a blood count indicates leucocytosis and a diminishing quantity of hæmoglobin, then an exploratory operation is quite justifiable whether a tumour is to be felt or not. On the other hand, the discovery of a tumour in the epigastrium does not warrant an operation. It is quite possible that under such circumstances the disease has extended beyond the reach of surgery, and therefore, unless there are distinct indications for palliative treatment—*e.g.*, the signs of pyloric stenosis—the patient is often better left to the care of the physician. Of course, in many cases an operation is undertaken in the almost vain hope of being able to do something to prevent the patient being condemned to certain death; but when ascites, jaundice, or definite evidences of dissemination are present, the surgeon should be very chary of interfering.

For cancer of the cardiac orifice, gastrostomy (p. 1005) may possibly be desirable, the artificial stoma being placed nearer to the pylorus than usual.

For cancer of the body of the stomach, a partial or total gastrectomy (p. 1007) may be feasible in the absence of massive adhesions; but the conditions which permit of such procedures are unusual. If there is any evidence of obstruction to the passage of food, a gastro-enterostomy (p. 1008) is undertaken; owing to the usual location of the carcinoma on the posterior wall, the surgeon may be driven to utilize the anterior operation. Sometimes the disease is so extensive that even this procedure is impracticable; the patient's nutrition is then likely to fail rapidly, but possibly life may be prolonged (if such be desirable) by the formation of an artificial opening into the jejunum (jejunostomy), through which he may be fed without using the stomach.

For cancer of the pylorus, operation is more frequently possible. If the mass is comparatively moveable, and there are but few adhesions, removal of the diseased portion of the organ may be undertaken, and even should secondary deposits be present in the liver, the patient is probably better off after such a procedure than if left alone. When the growth is firmly adherent to adjacent viscera, gastro-enterostomy is alone practicable, and will be most beneficial.

Failing all operative measures, the patient's nutrition must be maintained by such food as causes him the least discomfort, and considerable relief will be experienced from regular and systematic lavage of the organ. Opium will be needed for pain.

Simple Stenosis of the Pylorus results from a number of different conditions. It gives rise to hypertrophy and dilatation of the stomach, which becomes enlarged downwards, and forms a sac, in which food collects perhaps for days, and, undergoing fermentative changes, is finally ejected in large quantities, mixed with frothy mucus and a yeast-like scum containing an abundance of sarcinæ. The stomach may in time almost reach the pelvis, the pylorus being dragged down with it.

The causes of this condition are as follows: (1) Most frequently it is due to the healing of a *gastric ulcer,* situated within or close to the pyloric orifice; in the acute form, where the ulcers are small, spasm as a result of the associated hyperchlorhydria is an important element in aggravating the symptoms caused by a slight contraction. The treatment in these cases is at first medical, and includes daily washing out of the organ. Should it fail to give relief, operation is required, and consists in excision of the pylorus or in gastro-enterostomy. (2) It may result from the contraction of *extrinsic adhesions*. These may be massive or band-like; in the former case the pylorus is imbedded in the newly-formed fibrous tissue; in the latter it is kinked, and subsequently contracted. Such adhesions may be secondary to gastric ulcer, or may arise from an inflamed gall-bladder (peri-cholecystitis). Operative treatment is usually necessary in order to divide the adhesions, or to remedy the dilatation by gastro-enterostomy. (3) It is occasionally met with as a *congenital hypertrophy* of the pylorus, in which the overgrowth chiefly involves the muscular fibres. It usually occurs in male children, and the pylorus is transformed into a solid cylindrical mass, about an inch in length, pale in colour, and as hard as cartilage. Symptoms commence within two or three weeks of birth; after taking food there is not much evidence of pain, although the child may appear to be uncomfortable, and relief is obtained by vomiting. But little food appears to pass into the intestine, so that constipation is marked and the child soon wastes. The stomach becomes enlarged after a time, as in the other varieties, and the pylorus can sometimes be palpated as a moveable tumour. There has been a good deal of discussion as to the treatment of these cases, but practically it is limited to two procedures: (*a*) The pylorus is dilated by a modification of Loreta's method, metal dilators of the Hegar type being employed (Burghard); or (*b*) pyloroplasty is relied on by others. Gastro-enterostomy is, of course, desirable, but the mortality is high, the children not having sufficient vitality to stand such a serious operation.

Gastroptosis is a condition met with not very unfrequently, in which the stomach is displaced downwards and dilated, usually as a complication of a generalized enteroptosis (Glenard's disease, *q.v.*), and hence is likely to be associated with dropping of the liver and mobility of the right kidney. The *symptoms* produced are those of a chronic atonic gastritis with a dilated stomach; vomiting is not a marked sign, but acid eructations, gastric discomfort, and constipation are very troublesome, and the patient steadily loses weight; neurasthenic manifestations are prominent. The downward displacement of the stomach may be such as to permit the pancreas to be felt above the lesser curvature. Hæmatemesis is sometimes present, but the acidity is normal or diminished, and the diagnosis from gastric ulcer is thereby determined. Radiographic examination after a bismuth meal assists in determining the extent of the displacement (Fig. 468). *Treatment* consists in lavage and electricity to the organ in the first place with careful dieting, and external support by a suitable belt is of some value. In more advanced cases, operative treatment is necessary, and many different methods have been suggested. Theoretically, it is desirable to lift the stomach by folding up and shortening the lesser omentum, as suggested by Beyea; but unfortunately this structure is often so thin and attenuated as to render this procedure impossible. Eve* points out that it is essential in many cases to deal with the liver first, fixing it up to the anterior abdominal wall by suitable sutures, and then the lesser curvature of the stomach may be raised by passing sutures through it and through the liver itself along the attachment of the lesser omentum. Four or five sutures of this type will fix the stomach satisfactorily. It may be needful in a few cases to diminish the size of the cavity by the formation of a series of tucks or folds in the anterior wall by sutures passing from above downwards (*gastroplication*); whenever obstruction is present, gastro-enterostomy will also be required.

Acute Dilatation of the Stomach† is a curious condition occasionally met with in surgical practice, as an unexpected and unwelcome sequela of injury or operation, and that by no means necessarily limited to the abdomen. It is rather more common in medical work, arising either without apparent cause, or in the course of debilitating illnesses. It is characterized by a sudden onset, the vomiting of enormous quantities of fluid, and severe general symptoms, which usually terminate fatally in a few days. The stomach becomes enormously dilated, even sagging down into the pelvis, and the walls are more or less paralyzed, as peristalsis is rarely evident. The pathology of this condition is uncertain, but it is possibly due to constriction of the third piece of the duodenum by the root of the mesentery through a downward drag of the intestines. **Treatment** consists in regular lavage, and in some cases the abdominal decubitus has given relief; rectal alimentation is required. Surgical treatment is very unlikely to do good, unless there is some associated obstruction near the pylorus.

Operations upon the Stomach.

1. **Washing out the Stomach** is needed in cases of poisoning, in chronic catarrh, in dilatation of the organ, and as a preliminary to some operations in which its cavity is to be laid open. It may be accomplished by the ordinary stomach-pump, or by the simpler method of passing a long tube of good-sized calibre, to the upper end of which is attached a funnel. Fluid is introduced through the funnel, and syphoned out by lowering it below the level of the stomach.

2. **Gastrotomy,** or opening the stomach, is required for the removal of foreign bodies from it or from the lower end of the œsophagus, for exploratory purposes, and as a means of dilating simple strictures of either the pyloric or cardiac orifices (Loreta's operation).

Operation.—An incision is made in the middle line above the umbilicus unless there is some special indication to the contrary.

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* Sir F. S. Eve, *Transactions of Medical Society*, vol. xxxiii., p. 252.

† For further details, see 'Acute Dilatation of the Stomach,' by H. Campbell Thomson, M.D. Baillière, Tindall and Cox, 1902.

The peritoneum is opened, and the stomach recognised by its position immediately under the liver, and by the thickness, pink colour, and opacity of its walls. If the omentum or transverse colon presents in the wound, it must be pushed down, and the stomach looked for above. The spot where the stomach is to be opened is now selected, and the part drawn out and carefully packed around with sterilized gauze so as to prevent contamination of the general peritoneal cavity. The incision is made in the long axis of the stomach, and the finger inserted. The removal of a foreign body must be undertaken with great care, so as not to inflict injury on the organ, the wound being enlarged, if necessary. The stomach is subsequently closed by Czerny-Lembert sutures, and replaced; all traces of blood, etc., are removed, and the external wound is closed in the usual way.

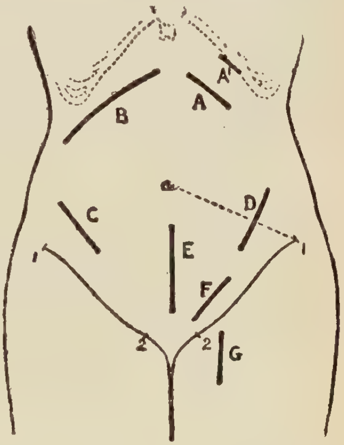

Fig. 473.—Incisions utilized in Various Abdominal Operations.

A, Fenger's incision for exposing the stomach; A^1, additional incision in Frank's gastrostomy; B, incision for exposing the gall-bladder; C, incision for operations on appendix; D, left iliac colostomy; E, median incision for ovariotomy or suprapubic cystotomy; F, for radical cure of inguinal hernia or varicocele; G, for femoral hernia; 1, anterior superior iliac spine; 2, pubic spine.

The *cardiac orifice* is not easily reached, as it lies deeply just in front of the aortic opening in the diaphragm. It can be dilated by the fingers or by suitable dilators, and a foreign body by this means removed from the lower end of the œsophagus. The utmost gentleness must be observed in this proceeding, as serious symptoms may be caused by irritation or injury of the pneumogastric nerves, the terminations of which pass through this opening in the diaphragm.

The operations on the *pyloric orifice* are dealt with below.

3. **Gastrostomy** consists in the formation of a permanent artificial opening into the stomach, through which the patient can be fed. It is needed in cases of malignant disease or intractable stenosis of the œsophagus, where the patient is exposed to the risk of starvation, owing to his inability to take nourishment. It is most important that the opening should be of a valvular type so that there shall be no escape of gastric juice, followed by irritation and digestion of the surrounding skin, which were so constantly seen in the old days. The chief methods of operation are those known as Frank's, Witzel's, and the Kader-Senn procedure.

Frank's Operation.—Fenger's oblique incision (Fig. 473, A) for exposure of the stomach is first made, the viscus withdrawn and examined, and a silk sling passed through the serous and muscular coats at the site selected for the artificial opening, so that a cone-shaped portion of the wall can be drawn up into the wound. The parietal peritoneum is then sutured all round to the base of the cone, so as to shut it off from the general serous cavity. A second incision (A^1), about 1 inch in length, is now made on the outer side of the first wound, parallel to it, and about 1½ inches from it. The bridge of skin and subcutaneous tissue between the two is separated from the subjacent structures, and the apex of the cone of gastric wall drawn under the bridge into the second wound. A small opening is then made into the viscus through the apex, and the mucous membrane stitched accurately to the skin. The remainder of this incision is then closed in the ordinary way, as also the first. Healing readily occurs, and a valvular opening is established, through which the patient may be fed at once.

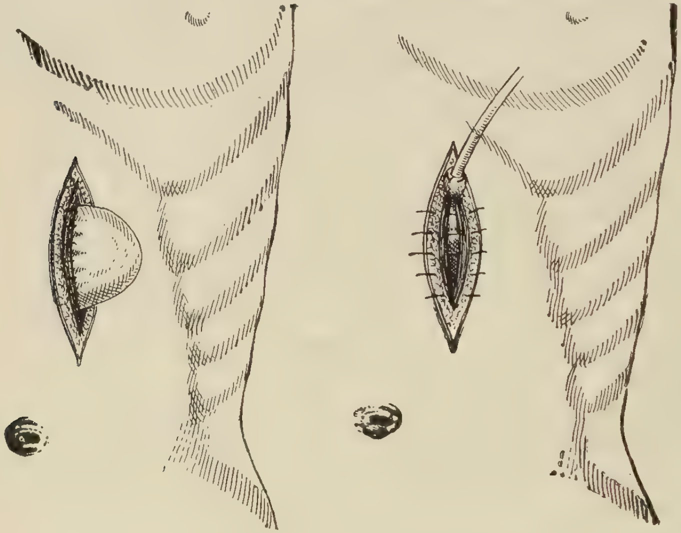
FIG. 474. FIG. 475.

GASTROSTOMY (FRANK'S MODIFIED OPERATION).

In Fig. 474 the base of the cone is seen sutured to the peritoneum and sheath of the rectus; in Fig. 475 the stomach has been opened, a tube stitched in, and the sutures passed through the rectus are in place.

As a modification of this procedure, a vertical incision (as suggested by Kocher) is employed instead of the oblique, extending for 3 or 4 inches downwards from the eighth costal cartilage and passing through the substance of the rectus muscle (Fig. 474), which is split by the fingers or handle of the knife into two portions. A cone-shaped portion of the stomach wall is withdrawn, and its base stitched to the parietal peritoneum and posterior layer of the sheath of the rectus. A small hole is made in the apex of the cone, and into this a piece of rubber drainage-tube, free from lateral openings, and not larger than a No. 10 catheter, is stitched, so that about $1\frac{1}{2}$ inches project inside the cavity (Fig. 475). The halves of the rectus muscle are freed from the posterior layer of the sheath and drawn together by sutures, so as to cover in all the exposed gastric wall except the apex of the cone, which with the tube is drawn to the upper end of the wound, and projects from it. The incision in the skin is then closed, and finally the serous and muscular coats of the projecting portion are carefully stitched to the skin. The results of this procedure have been most satisfactory, many cases having run their course without a drop of gastric juice escaping. The amount of food at first administered is small, and rectal feeding may be required in addition; but it is gradually increased until perhaps 17 ounces can be retained four times a day. The patient should be kept in the recumbent posture for three weeks.*

Witzel's Operation consists in making a valvular opening into the stomach by introducing and stitching a tube into it as in the last proceeding, and then burying the projecting portion as far as possible by suturing the serous and muscular coats together over it. The stomach is then fixed to the abdominal parietes and the skin closed. The result of this operation is very good, but the fixation to the abdominal wall is not so secure as in the former plans, and inasmuch as the newly-formed passage is lined with serous membrane contraction is liable to occur. It may be employed advisably when the stomach is small, and it is difficult to find enough tissue for the performance of Frank's operation.

In the *Kader-Senn Operation* a tube is stitched into the stomach and buried in the stomach wall by a series of purse-string sutures introduced at intervals of about $\frac{1}{2}$ inch. The stomach itself is then secured to the margins of the abdominal incision.

4. **Gastrectomy.**—A good many cases have now been reported in which a limited portion of the gastric wall has been removed successfully, either for simple or malignant ulcers or growths. Incisions are made so as to include the mass, and the wound is subsequently closed by Czerny-Lembert sutures.

Total excision of the stomach has been undertaken for extensive malignant disease, which, however, has left enough of the œsophageal end free to allow of its apposition and fixation either to the upper end of the duodenum, or, if that cannot be brought across to it, to a suitable coil of the jejunum.

5. **Partial gastrectomy for malignant disease** of the pyloric end of the stomach is now frequently undertaken and with excellent results, if the patient is not too debilitated and if too many adhesions are not present.

Operation.—The abdomen is opened by a median incision, through which the diseased area is explored, and a final decision made as to the practicability or not of removing it. If an operation is determined on, the growth is carefully isolated from surrounding parts by dividing the attachments of the great and lesser omenta, any enlarged glands being also included in the scope of the operation. Clamps are then applied to the stomach and duodenum, and the surrounding part of the abdomen carefully protected with sterilized gauze. The mass is now removed (Fig. 476), the incisions being so placed as to extend beyond the pylorus about ¾ inch into the duodenum on the one side, and on the other so as to include the greater portion of the lesser curvature, thereby removing the lymphatic glands. Bleeding-points are secured, and the two incisions completely closed, no attempt being made to appose or unite them. The first part of the jejunum is then drawn up, and an ordinary gastro-enterostomy performed; this is sometimes undertaken as a preliminary operation.

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* For further details, see Carless, 'On Gastrostomy,' King's College Hospital Reports, vol. v., 1897-1898, and in *Edinburgh Medical Journal*, July, 1902.

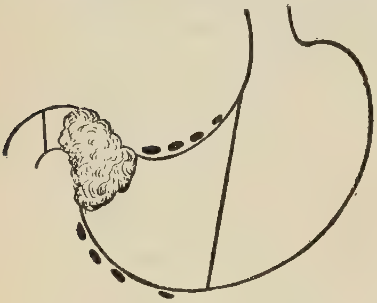

Fig. 476.—Cancer of Pylorus, indicating the Situation of the Lymphatic Glands along the Two Curvatures, and of the Incisions needed to include them.

The chief danger of the operation is shock, but if this can be avoided by careful protection of the viscera, by the prevention of hæmorrhage, and by rapidity of execution, a good result may be expected. The patient is fed *per rectum* for the first forty-eight hours, if possible, but after that interval small quantities of fluid may be allowed, and the dietary gradually increased.

6. **Pyloroplasty** consists in incising the pylorus and reclosing the incision in such a way as to increase the calibre of the tube. It has been performed for various types of stricture, but is now rarely employed (except for congenital stenosis), having been replaced by gastro-enterostomy. The operation commences by clearing the pylorus from adhesions. A longitudinal incision is then made through the stricture, and by a little careful manipulation this wound can be opened out and brought together in a transverse manner so as greatly to increase the lumen of the orifice (Fig. 477). Two rows of stitches are inserted, one through the mucous membrane, and the other through the muscular and serous coats.

7. **Gastro-enterostomy,** or, more correctly, gastro-jejunostomy, is constantly resorted to in the treatment of gastric, pyloric, or duodenal lesions, and in careful and skilful hands the death-rate is now small (well under 10 per cent.). *Indications.*—1. For obstruction to the onward course of the food, whether in the stomach, pylorus, or duodenum, and whether simple or malignant in origin. 2. For persistent phenomena of ulceration, either of stomach or duodenum, in spite of suitable treatment, but it is doubtful whether

it is of much value apart from a lesion which obstructs more or less the passage of food. 3. For recurrent hæmorrhage under similar conditions, in order to put the parts at rest by rapidly emptying the stomach, or by diverting the food from the duodenum. 4. As a part of the modern operation of pylorectomy or hemi-gastrectomy.

The operation consists in the formation of an artificial communication between the stomach and intestine. It is important that the selected portion of bowel should be the upper part of the jejunum, since, if the communication is established too low, a much greater absorbing surface is isolated, with the result that, even if the operation is immediately successful, the patient gradually loses ground owing to lack of nutriment; and the rapidity of the emaciation will increase as the communication is placed further from the duodenum.

Operation.—The abdomen is opened in the middle line and the stomach is readily found; a careful examination of the parts is made to confirm the necessity for the anastomosis and to select the most favourable site. This should be placed on the posterior wall of the stomach, if possible, close to the greater curvature, but well away from the growth or ulcer, and yet as near to the pylorus as is practicable. The selected spot in the jejunum must be as near to its commencement as possible, so as to leave only a short loop between its origin and the anastomosis. The anti-mesenteric border is utilized, and the jejunum must be so placed that the peristaltic wave passing from stomach to jejunum shall be continuous—*i.e.*, shall travel from left to right. To find the upper end of the jejunum, the transverse colon is withdrawn from the wound, together with the omentum. By tracing down the transverse meso-colon to its attachment the termination of the duodenum is reached as it crosses the middle line at the lower border of the pancreas, and the coil of bowel which emerges on the left side is necessarily the commencement of the jejunum. It is now possible to decide finally whether the anastomosis is to be effected to the anterior or posterior wall of the stomach.

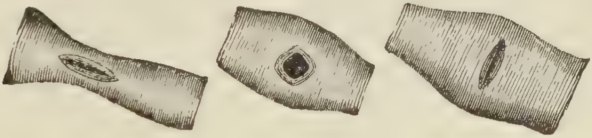

FIG. 477.—PYLOROPLASTY.

The contracted bowel is divided longitudinally, and the aperture thus made opened out, so that it can be brought together transversely.

(1) The *anterior* operation (Fig. 478) has fallen into disrepute of recent years, but with care excellent results can be obtained when the condition of affairs prevents the posterior wall from being employed. The objections to it are twofold: (*a*) The jejunum is drawn up over the transverse colon, and may possibly constrict it and lead to obstruction; this is the more likely to occur when the

opening in the jejunum is as near as possible to the duodenum, a desirable arrangement from many other points of view; and (*b*) the necessary drag of the gut is apt to bring the two ends parallel to each other, and thus produce a spur, or kink, by means of which the bile is directed into the stomach instead of into the efferent limb, thus establishing a vicious circle. Severe bilious vomiting results, which may prove fatal. The actual method of anastomosis is similar to that for the posterior operation.

(2) In the *posterior* operation of Von Hacker the jejunum is united to the posterior wall of the stomach through an opening in the transverse meso-colon, the lesser sac of the peritoneum being thereby traversed. Long metallic clamps, with or without rubber guards over the blades, are then applied to the stomach and intestine in such a way that they can be brought easily into apposition one with the other (Fig. 479), and with sufficient force to prevent extravasation of the contents, and to control hæmorrhage. A suitable packing of strips and abdominal cloths is then made, and all other viscera are replaced. Incisions, 2 inches in length, are made into stomach and intestine so as to correspond exactly, and any fluid which escapes is received on swabs or gauze strips.

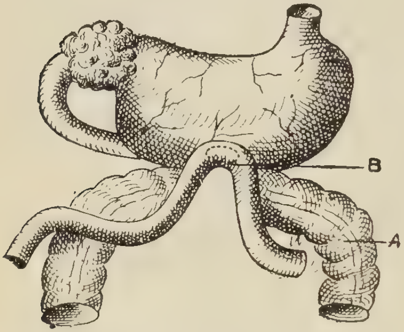

FIG. 478.—ANTERIOR GASTRO-ENTEROSTOMY.

A, Transverse colon; B, jejunum dragged up over the colon and omentum (purposely omitted) to be brought into apposition with the stomach.

The actual anastomosis is effected by simple suturing without the aid of any other mechanical contrivance; either sterilized silk or iodized catgut may be employed for the purpose. The suturing is undertaken in four stages. Firstly, a sero-muscular suture secures the posterior aspects of the viscera in apposition, the stitches extending beyond each end of the incision. Then the mucous membranes of the stomach and jejunum are united by a continuous suture. This may be performed in two sections, back and front, or one stitch may suffice for the whole anastomosis. Finally, the anterior sero-muscular suture completes the junction. Occasionally a few extra supporting stitches are required in addition to the two rows, and it is well to secure any large vessel going to the site of anastomosis by passing a suture under and tying it. The suturing must be accurate and close, as one depends on it to prevent bleeding from the divided visceral walls.

The usual peritoneal toilette follows: clamps are removed, blood is sponged away, swabs and strips of gauze are removed and counted, the viscera replaced, and the abdominal incision closed.

The *after-treatment* consists in the adoption of the sitting posture, and in abstaining from stomach-feeding for twenty-four to forty-eight hours, if practicable, rectal alimentation being resorted to in the interval. Hæmorrhage from the divided visceral walls is sometimes troublesome, the patient vomiting blood-stained fluid. Ice is then applied to the epigastrium, and a full dose of ergotin administered hypodermically, or 20 grains of lactate of calcium by rectum. Not unfrequently there will be some regurgitation of bile into the stomach, and this may lead to troublesome vomiting for a few days; but if the junction is satisfactory, it soon passess off, especially when food is administered by the mouth, as may usually be undertaken on the third day, or earlier, if necessary. At first only fluid nourishment should be permitted, but in a week's time soft solids may be given, and gradually a more liberal diet is ordered. The effect of the operation is necessarily only palliative when cancer is present, but the general condition often improves considerably for a time, and the final exitus lethalis is associated with less suffering.

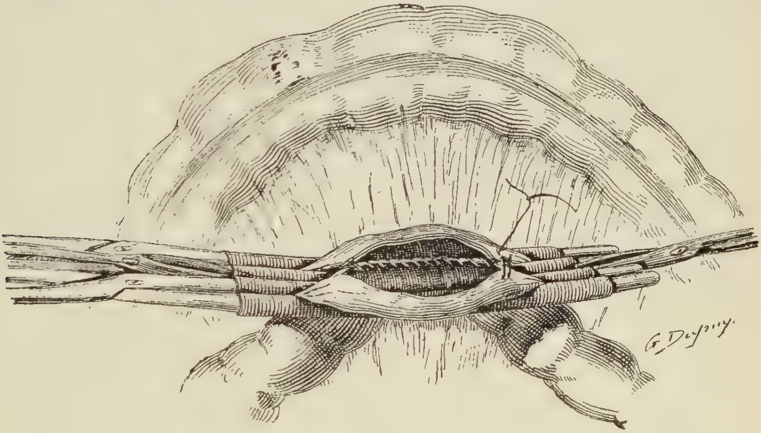

FIG. 479.—POSTERIOR GASTRO-ENTEROSTOMY.

Clamps guarded by rubber tubing have been applied to the stomach and jejunum, and their apposition is maintained by clipping the rubber tubing with Spencer Wells forceps at each end. The incisions have been made, and the posterior walls have been sutured together.

Should serious biliary vomiting occur, the patient must sit up and the stomach be washed out. Failing that, it may be necessary to open the abdomen, and establish a fresh opening between the afferent and efferent coils. To prevent the possibility of such an occurrence, Roux has suggested making a **Y**-anastomosis. The jejunum is cut across, the lower segment being implanted at right angles into the stomach wall, and the upper or duodenal end into a second opening in the gut lower down. Excellent results have followed this procedure.

Peptic Ulceration may occur at the site of anastomosis or a little below it, but is uncommon, except after the anterior operation, and even then only occurs in 2 per cent. of the cases. It may determine pain and vomiting after food, accompanied perhaps by hæmorrhage or perforation. Treatment is as for ordinary ulcer of the stomach.

8. **Finney's Operation**, or gastro-duodenostomy, is employed by some surgeons as an alternative to the gastro-jejunostomy just described. It consists in an anastomosis between the second piece of the duodenum and the immediately adjacent stomach. It has its advocates, but has not come into general favour.

Ulcers of the Duodenum are very similar in nature and origin to those of the stomach, to which indeed they may be secondary. They occur most frequently in men thirty to forty years of age, and often without any obvious cause. Oral sepsis is not uncommonly present, as also hyperchlorhydria; in some cases chronic nephritis or arteriosclerosis has existed, and in others the lesion follows some operation. The ulceration which forms a very occasional sequela of burns has been already alluded to (p. 126). The first part of the duodenum is that usually affected, and the anterior rather than the posterior wall; the character of the ulcer is similar to that seen in the stomach.

The **Symptoms** are tolerably characteristic, even apart from the dangerous complications, hæmorrhage, perforation, and stenosis. The patient, who may appear to be fairly well nourished, complains of pain coming on after meals, not immediately, but after an interval of two or three hours, and often relieved by taking more food. Beginning with a sense of fulness and heat in the epigastrium, it develops into acute pain located in the right hypochondrium and shooting through to the back. On examination of the abdomen a tender spot is usually to be detected a little above and to the right of the umbilicus (Fig. 480, D). The patient complains much of acid eructations, but vomiting is not a very frequent symptom; when present, it may relieve the pain. The ejecta may contain a certain proportion of bile. The patient is constipated and loses weight during an attack. Frequently he has intervals of complete freedom from pain, in which he can digest anything and enjoy life. In a considerable percentage of cases, moreover, the condition is absolutely latent and free from symptoms until acute manifestations of perforation or hæmorrhage supervene.

Perforation usually involves the first part of the duodenum, and may be intra- or retro-peritoneal. The conditions produced are practically identical with those following a perforated gastric ulcer, but with slight differences due to the change of situation. Thus, with the usual acute intraperitoneal perforation the fluid on escaping from the duodenum is guided downwards by the ascending mesocolon to the right iliac fossa, and hence the symptoms of acute appendicitis are somewhat simulated; but it may be possible to locate the primary pain to the hypochondrium. The mischief soon spreads, however, to the general cavity, and the localizing symptoms disappear. The effusion includes the fluid duodenal contents, often very abundant and perhaps bile-stained, and usually free gas. If the opening in the duodenum is small and the contents escape slowly, a subphrenic or subhepatic abscess may form, but the adhesions are not very firm, and it may burst secondarily into the general serous cavity. A retroperitoneal perforation of the duodenum is the origin of a subacute subphrenic abscess, which is placed behind the peritoneal cavity, but always to the right side of the falciform ligament.

Hæmorrhage is evident in most cases in the form either of hæmatemesis or melæna. The history generally given is that during a dyspeptic attack a sensation of faintness occurs, followed by anæmia. Part of the blood lost may be vomited, but the greater portion passes down the intestine, giving rise to melæna. The patient may die from loss of blood, and then usually some large branch of the pancreaticoduodenal vessels has been laid open; more frequently it ceases after a time, but may be repeated again and again.

Stenosis of the duodenum results from the cicatrization of ulcers, and may lead to frequently repeated vomiting, dyspepsia of an intractable type, a greatly distended stomach, and emaciation to an alarming degree.

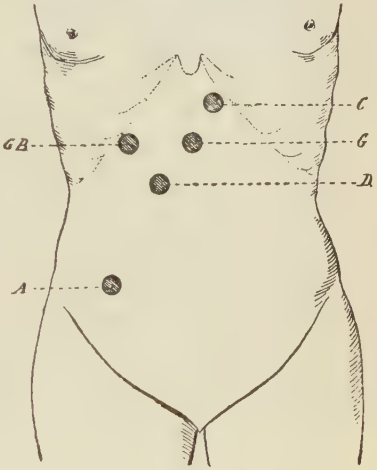

FIG. 480.—TENDER SPOTS IN ABDOMINAL LESIONS.

C, In ulcer of stomach near the cardiac orifice; G, in the ordinary type of gastric ulcer; D, in duodenal ulcer; GB, in affections of the gall-bladder; A, in appendicitis (McBurney's spot).

Treatment.—If a diagnosis can be made and no complications are present, the same treatment is instituted as for gastric ulcer —viz., rest in bed and rectal alimentation. Persistence of symptoms—*e.g.*, vomiting, hæmorrhage, etc.—is treated by gastrojejunostomy, and the results are most satisfactory. Perforation, of course, needs immediate operation, as described for the stomach (p. 994). In the earlier stages of a duodenal perforation, the incision will probably be located along the right semilunar line for 4 or 6 inches. The opening, when found, should be stitched up in the transverse axis of the bowel, so as not to diminish its calibre. Stenosis of the duodenum is treated most successfully by gastroenterostomy, and there are few operations in surgery which give more gratifying results.

Affections of the Intestine.

Bismuth Radiography of the intestines is often of great assistance in the diagnosis of the condition and position of various lesions. As already mentioned (p. 989), the stomach should be empty in about four hours, and about the same time (four and a half hours) the bismuth should begin to enter the cæcum; it is not usually possible to trace the bismuth in the duodenum or along the small intestine. There is not uncommonly some hindrance to the escape of bismuth through the ileo-cæcal valve, and the bismuth may collect in the lower end of the ileum, and be seen in the pelvis. The hepatic flexure is generally reached in five to eight hours, the splenic flexure in seven to fourteen hours, and the iliac colon in eight to sixteen hours; the bismuth normally disappears from the bowel in from twenty-four to thirty-six hours. Irregularities in the course of the intestine can often be detected by this means, such as strictures, kinks, diverticula, etc. The appendix can occasionally be recognised, but difficulty in the escape of the bismuth from the small to the large intestine may suggest the existence of adhesions binding down the appendix. Too much stress must not be laid on radiographic reports apart from a careful consideration of the clinical phenomena. Bismuth is heavy, and a downward displacement of the intestine when loaded with it is a natural consequence; it is also somewhat astringent in type, and determines contraction of the intestinal wall, so that the diverticula of the colon become exaggerated. Finally, it must ever be remembered that radiographs are shadow pictures, and unless taken stereoscopically it is possible to imagine the existence of severe kinks due to the overlapping of the shadows, when in reality nothing of this type is present; this warning especially needs emphasis in interpreting radiographic representations of the flexures of the colon.

Congenital Conditions are occasionally met with affecting the intestine, and perhaps giving rise to serious complications. (*a*) The most common of these consists in what is known as *Meckel's diverticulum,* which occurs as an outgrowth from the lower end of the ileum. It may be patent for 1 or 2 inches, terminating possibly in a fibrous cord, which floats free among the intestines, or may contract adhesions, and thus determine an internal strangulation; sometimes it persists as an open tube as far as the umbilicus, giving rise to a congenital fæcal fistula. It is due to non-obliteration of the omphalo-mesenteric duct. Many forms of acute abdominal trouble have been caused by this structure, and even inflammatory attacks similar to acute appendicitis; gallstones or enteroliths have lodged within it and caused perforative peritonitis. (*b*) *Congenital stenosis* of the duodenum occurs opposite the entrance to the common bile duct, and a similar condition may arise in the lower part of the ileum at a spot corresponding to the site of Meckel's diverticulum.

Contusion of the Intestine may result from any serious blow on the abdomen, and necessarily varies in its effects with the nature and force of the injury, the amount of distension of the gut, and the strength and power of resistance of the parietes. In its simplest form, it merely produces a little bruising of the intestinal wall, followed by a subacute or chronic enteritis, from which with care the patient quickly recovers. In the more severe cases, an acute enteritis ensues, due to bacillary invasion, which may even run on to ulceration or sloughing of the coats of the bowel. The latter result

BISMUTH RADIOGRAPHY OF THE INTESTINES.

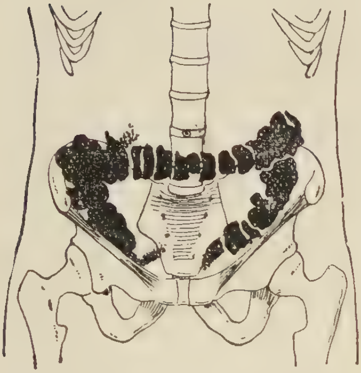

FIG. 481.—SLIGHT DOWNWARD DISPLACEMENT OF TRANSVERSE COLON.

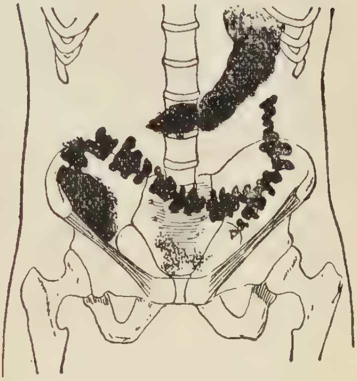

FIG. 482.—ENTEROPTOSIS WITH TRANSVERSE COLON IN THE PELVIS.

The stomach is occupied by a bismuth meal given two days after the former, part of which had not escaped.

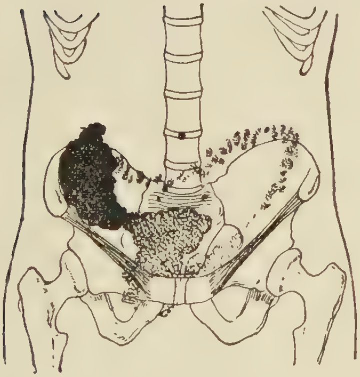

FIG. 483.—INTUSSUSCEPTION OF CANCER OF CÆCUM INTO TRANSVERSE COLON.

The bismuth does not extend much beyond the hepatic flexure; the pre-operative diagnosis was cancer of the transverse colon. For specimen removed from this case, see Fig. 485.

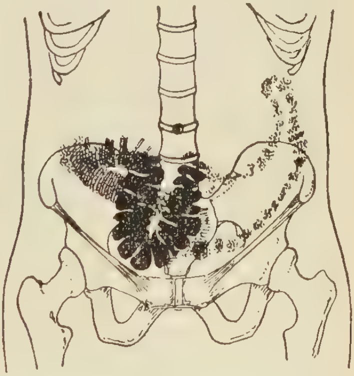

FIG. 484.—ENTEROPTOSIS WITH OBSTRUCTION IN TRANSVERSE COLON.

The bismuth can just be traced in the splenic flexure and beyond; it is evidently retained in cæcum and ascending colon.

is more likely to follow if the mesentery has also been involved in the injury so as to produce thrombosis of the mesenteric vessels. Under these circumstances, the final issue depends largely upon the rapidity of the inflammatory process. If adhesions have had time to form between the parietes and the injured gut, the mischief is limited, and the patient may recover with a fæcal fistula, the formation of which has been preceded by a localized intraperitoneal abscess, containing extremely offensive pus, owing to the presence of the *B. coli*, which has migrated through the intestinal wall. If, however, the inflammatory affection is rapid in its onset, and adhesions have not had time to develop, acute diffuse peritonitis is almost certain to follow. When the injured portion of the bowel is retro-peritoneal, as in the duodenum or colon, a retrō-peritoneal abscess may form.

The **Symptoms** of intestinal contusion consist primarily of shock and pain. The amount of shock varies necessarily with the severity of the injury and the nervous susceptibility of the patient. The pain may not be severe at first, but is always very marked subsequently, and increased by examination, movement, or during violent respiratory efforts. To limit such movement, the abdominal parietes are maintained in a state of firm contraction, and can be felt hard and resistant. Vomiting may be present, but is not a marked feature. The later symptoms necessarily vary with the course taken by the case, and need not be described in further detail.

Treatment is conducted along the same lines as that of contusions of the abdominal wall (p. 971); viz., where there is no absolute evidence of rupture, an expectant attitude may be adopted, but the surgeon must be ready to interfere should any grave or suspicious symptoms arise. Acute enteritis induces diarrhœa and the passage of blood-stained mucus, and such symptoms will indicate the use of bismuth, and perhaps a little morphia, whilst a fluid diet or rectal feeding is alone permissible.

Rupture of the Intestine follows abdominal injuries of a more severe character, such as when a cart or cab has traversed the abdomen, or when the patient has been tightly squeezed or kicked. The bowel does not always give way at the point of impact, but occasionally at a distance from it; under these circumstances the tear is more likely to be ragged and irregular, whilst if it yields at the point struck, the gut may be cleanly torn across. The parts most frequently affected by this form of injury are the junction of the moveable jejunum with the fixed duodenum, and the lower 3 feet of the ileum. The fluidity of the contents of the small intestine has a grave prognostic significance, since they are readily diffused.

The early **Symptoms** consist of severe and usually lasting shock, accompanied by intense abdominal pain, which may at first be localized. If there is an abundant escape of the intestinal contents, a virulent form of acute peritonitis follows immediately, from which the patient rapidly succumbs. If, however, the gut was empty at the time of the accident, the symptoms are less severe; acute peritonitis ensues, but it is slower in onset, and some attempt to limit it is observed. An important diagnostic point is that the maximum tenderness is always fixed to a localized area. Free gas is sometimes, but not frequently present in the peritoneal cavity, as in rupture of the stomach In a few cases emphysema of the abdominal walls has been noted, and in the absence of thoracic injuries or of diffuse cellulitis is an absolutely certain sign of rupture of the intestinal tube. Vomiting occurs, but not to an excessive degree; if blood is found in the vomit, it suggests that either the stomach or upper part of the intestinal canal has been injured. Occasionally a blood-stained motion is passed, but only late in the case.

The **Diagnosis** of a ruptured intestine is always a matter of uncertainty in the absence of emphysema of the abdominal walls, which is very uncommon. Formerly it was supposed that free air or gas in the peritoneal cavity would be certain to find its way up between the liver and the abdominal wall; hence loss of the liver dulness was considered an important sign. It is by no means certain, however, that the gas does travel in this direction, and a resonant note over the liver is a common result of distension of the colon. If, however, the abdominal wall is retracted and not distended, the existence of this sign is suggestive. The amount of shock is also an uncertain guide, as it varies both in degree and duration. The temperature does not help much, although a secondary fall below normal after reaction, especially if associated with increasing rapidity of pulse and respiration, is very suggestive of grave mischief. The presence of an area of deep fixed tenderness and pain with, perhaps, a rigid abdominal wall over it, and the incidence of early acute peritonitis, are probably the only signs that we can depend upon with any certainty. The history and nature of the accident are important, and should be carefully investigated.

In the non-existence of any distinct signs of rupture, **Treatment** in the early stages can only be expectant, and directed towards combating the shock and relieving the pain. A small dose of opium should be administered with this object, and also to check peristalsis and hinder further extravasation of the intestinal contents; but as little as possible should be given, since it tends to mask symptoms. If the surgeon has good grounds for suspecting that the intestine is torn, he ought at once to undertake an exploratory laparotomy, and deal with the condition found.

Punctures or **Stabs** involving the intestine lead to a similar series of phenomena; but the diagnosis may be easier, as gas or fæcal material may escape through the external wound. The direction of the incision in the gut is of importance, since a longitudinal cut (running parallel to the axis of the bowel) is more likely to gape than a transverse one, owing to the greater power of the circular muscle fibres; a small puncture may be almost closed by a protrusion of mucous membrane. Shock is not necessarily so severe as when the intestine is ruptured by violence without penetration; abdominal pain is always present, and the phenomena of acute peritonitis may quickly follow.

Treatment.—Every case of suspected penetration should be carefully explored. The skin and superficial parts of the wound are first thoroughly purified, and then the wound is enlarged and the deeper parts are examined. If the peritoneum is not opened, the different layers of the abdominal wall are sutured together. If the peritoneum has been involved, the opening in it should be enlarged, so as to explore the viscera and determine with certainty whether or not the gut has been wounded. If a small punctured or incised wound of the intestine is present, it is invaginated and closed by a purse-string stitch or by a row of Czerny-Lembert sutures. If a more extensive lesion exists, excision of the damaged portion may be necessary; but if the patient is deeply collapsed from the supervention of peritonitis, it may be wiser to bring the divided ends to the abdominal wall, and form a temporary artificial anus, which is subsequently dealt with when the patient's general condition has improved. As to the treatment of the resulting peritonitis, the reader is referred to what has been written concerning rupture of the stomach (p. 990).

For **Gunshot Wounds** and their treatment, see pp. 248 and 249.

Perforation of the Intestine arises from many different causes, such as the impaction of a foreign body, or the yielding of an intestinal ulcer, as occurs in tuberculous disease or typhoid fever, or from that form of enteritis which follows strangulated hernia. The phenomena resulting from the perforation of an ulcer of the stomach or duodenum has been already discussed (pp. 994 and 1012), and another variety caused by perforation of the appendix will be alluded to subsequently (p. 1044).

When the jejunum or upper portion of the ileum is involved, perforation is usually due to the impaction of a foreign body, such as a fish-bone, or to yielding of a tuberculous ulcer. In the former case, general peritonitis is almost certain to follow, but in tuberculous cases the lesion is of a more chronic type, and then adhesions may form, allowing an intraperitoneal abscess to develop, and should it open externally, a fæcal fistula follows. In not a few cases the process of cicatrization may lead to a spontaneous closure of the fistula, and no operation should be undertaken until sufficient time has elapsed to determine whether or not this will occur.

In the lower portion of the ileum, *typhoid fever* is the most usual cause of perforation. Occasionally in cases of the so-called 'ambulatory typhoid' it is the first evidence of the presence of the disease, but it generally occurs about the end of the second or in the third week, and rarely more than one perforation is present. It is most commonly seen in bad cases associated with meteorism and hæmorrhage, but is not limited to such. The symptoms are usually those of sudden collapse, as indicated by a falling temperature and a quick and feeble pulse, whilst severe and persistent abdominal pain followed by increasing distension indicates the development of general peritonitis. Even when the patient is already collapsed by the disease, some slight fall of temperature with acceleration of the pulse may occur, associated with abdominal pain and meteorism. Early rigidity of the belly wall is an important diagnostic sign, whilst there may be some irritability of the bladder. The only *treatment* which holds out any prospect of saving the patient is operation, but owing to his depressed condition the outlook is not particularly bright. Obviously, when he is moribund, it is useless to interfere; but the facts that of some 300 cases operated on and reported 27 per cent. have recovered, and that the death-rate has gradually fallen from 90 to 69 per cent., indicate that in cases diagnosed early a fair proportion of success may be anticipated. The abdomen should be opened in the middle line below the umbilicus, or directly into the right iliac fossa, and if the lesion is not at once obvious, the ileum is sought for at its junction with the cæcum, and the bowel brought up and carefully examined inch by inch till the perforation is found; it may then either be closed by sutures introduced so as to close the wound in the transverse axis of the gut and thus diminish the risks of a subsequent stenosis, or the edges of the ulcer stitched to the margins of the wound so as to create a temporary fistula. The peritoneum is cleansed and drained in the usual way, after determining that no second perforation is present or imminent.

In the large intestine the most common cause of perforation is ulceration due to chronic obstruction or malignant disease. Masses of fæces accumulate within the bowel, and by their pressure give rise to inflammation of the walls, which runs on either to ulceration or to actual necrosis. Most usually the peritoneum is by this means laid open, either just above the growth, or as a consequence of its local extension; sometimes, however, the bowel gives way at a higher level, where fæces mainly accumulate, and then generally in the cæcum. In many cases acute perforative peritonitis follows, but occasionally the mischief is limited, and an intraperitoneal abscess forms, followed by a fæcal fistula.

Foreign Bodies in the intestine are of three types:

1. *Gallstones* give rise to no symptoms unless they are of large size; the smaller ones enter the canal through the common bile-duct after an attack of biliary colic, and are voided in the stools. Larger stones usually gain entrance to the intestine by ulceration from the gall-bladder into the duodenum. A coating of fæcal matter is likely to form around them, and thus they increase in size as they pass downwards, whilst the intestine gradually diminishes in calibre from the duodenum to the ileum, so that they are likely to become impacted in the lower ileum. Women over fifty are most often the subjects of this condition, and there may be only a history of some inflammatory condition in the region of the gall-bladder, and none of biliary colic.

2. *Enteroliths* are of three classes: (*a*) Calculi of phosphate of lime or inspissated fæces form around some foreign body as a nucleus. (*b*) Masses of indigestible vegetable material may be matted together with inspissated fæces, mucus, etc.; they are said to be not uncommon in Scotland (the so-called *avenolith*), consisting largely of the husks of coarse oatmeal. They have also been known to consist of

hair, or of cocoanut fibre in a patient engaged in mat-making. (*c*) Calculi have been found consisting of insoluble mineral salts—*e.g.*, carbonate of magnesia or chalk, taken as medicine. Whatever their origin, such enteroliths are likely to become impacted near the cæcum, and may cause acute obstruction. In thin persons their presence may be detected by palpation of the abdomen.

3. *Foreign Bodies accidentally or intentionally swallowed* occasionally pass through the stomach and become lodged in the intestinal canal. Lunatics and children are most frequently affected, and in the former the most astonishing collections are occasionally found.

The **Symptoms** caused by such conditions will be either those of intestinal obstruction (p. 1130) or of perforation. In the latter the process is usually gradual, rather than sudden, giving time for adhesions to form, thereby limiting the mischief. Suppuration follows, and possibly the foreign body may be extruded naturally or removed by the surgeon through the abscess cavity, with or without the formation of a fæcal fistula.

Small spiculated foreign bodies—*e.g.*, fragments of glass or metal, the husks of cereals, etc.—may sometimes lodge in the pouches of the colon, and give rise to localized inflammatory phenomena, perhaps in one or more of the appendices epiploicæ. The symptoms will very closely resemble those of a localized appendix abscess, and similar operative treatment will be required. In other cases a chronic inflammatory mass may be produced which simulates a neoplasm of the intestinal wall, and may disappear spontaneously or after exploration. The supposed cure of certain cases of intestinal cancer by quack remedies may be explained in this way.

Enteritis, or inflammation of the mucous membrane of the intestine, is a condition usually treated by the physician; occasionally it complicates surgical cases and needs effective treatment. Thus it may follow the exposure of a coil of intestine in the depths of a wound which has to be packed for drainage purposes. Severe diarrhœa may result, and the inflammation may even spread through the whole thickness of the gut wall, and lead to the establishment of a fæcal fistula. Enteritis also occurs as a post-operative complication of strangulated hernia (p. 1121). Whatever its origin, it is always characterized by diarrhœa of varying type, and by pain or abdominal discomfort and perhaps vomiting. *Treatment* consists in the use of a bland diet—*e.g.*, milk—and the administration of soothing astringent drugs, such as bismuth and perhaps opium. It must not, however, be checked without ascertaining so far as possible that the causative irritant has been removed, and not uncommonly the best treatment to start with is the administration of a good dose of castor oil.

Colitis is an affection occasionally needing surgical treatment. The cause is usually chronic constipation, but bacteria of various types or the *Amœba coli* may be present. In the simpler cases (*mucous colitis*) the patient complains of griping pains in the course of the colon, diarrhœa, the passage of mucus in the stools, perhaps in membranous flakes, and definite tenderness of the colon on palpation. The appendix is not unfrequently inflamed at the same time, and one of the most tender spots may be over this organ. *Treatment* of this form consists in emptying the bowel by enemata, keeping the patient quiet in bed on a milk diet, and possibly ordering bismuth or a little chlorodyne. When the patient is convalescent and all tenderness has disappeared, the causative chronic constipation must be treated. Purgatives usually cause irritation and pain, and must be as far as possible avoided. Abdominal massage and the methodical use of the so-called Swedish exercises, which increase the power of the abdominal muscles, and thereby give tone to the relaxed colon, will often work wonders in these cases. The use of medicinal waters and irrigation of the colon, as practised at Harrogate and Plombières, often give excellent results. In a certain percentage of cases removal of the appendix does good in colitis, but before undertaking the operation the surgeon must be careful not to promise too much.

The graver cases (*ulcerative colitis*) are associated with the discharge of pus and the exfoliation of patches of mucous membrane. The patient's health may be profoundly affected in this disease, pus of a most offensive type pouring out from the rectum, or fever of a marked hectic character being present. The nutrition is necessarily impaired, and the patient wastes to a shadow. Under such circumstances, and especially when rectal irrigation has failed, the surgeon may be asked to make an artificial opening into the cæcum in order to permit of more thorough irrigation, and also perhaps to divert the intestinal contents. For the method of operating, see p. 1031. The fluid employed for irrigation must be bland, non-toxic, and unirritating. Warm saline solution should be first used, and subsequently a weak boric acid solution, or possibly, with great care, a 1 in 5,000 solution of nitrate of silver. The patient sits over a bed-pan, and the fluid is injected through the fistula from an irrigator; distension of the bowel must be avoided, and to this end the introduction of a rectal speculum to keep the anus open during the irrigation is desirable. Latterly the vermiform appendix has been used for this purpose; it is stitched into the wound and opened (*appendicostomy*), and the bowel irrigated through it. The escape of intestinal contents is less than if the bowel is opened, and subsequent closure of the fistula after the disease is cured is more easily effected. It is probable that some amount of stenosis of the bowel may result from the cicatrization of the ulcers in the colon, and then the fistula may have to remain permanently.

Tuberculous Disease of the Intestine usually occurs in the ileocæcal region, and manifests itself in two main varieties:

1. **Tuberculous Ulcers** are generally multiple, though occasionally single. They are of the usual tuberculous type, with undermined margins (Fig. 45, p. 183), and extend along the course of the bloodvessels and lymphatics—viz., around the gut, so that if they heal stricture is almost certain to follow. In their early stages they do not require surgical assistance, but later on obstructive phenomena

may supervene, and these may be due not only to the stenosis, but also to associated peritonitis; neighbouring mesenteric glands are usually infected, and together with the bowel and omentum may form a palpable mass, in the midst of which suppuration may occur. Should the abscess burst externally, a fæcal fistula may result. Operation may be needed for the relief of the obstructive phenomena, or for the suppuration, and some form of anastomosis, or even excision of the mass, may be required.

2. The disease is sometimes of a hyperplastic type, and is then chiefly limited to the cæcum, producing a well-marked tumour, which can be palpated from outside, known as the **Tuberculous Cæcal Tumour :** the disease is liable to extend along the ascending colon for some distance, and less frequently along the ileum. The intestinal wall is thick, congested, and infiltrated with a tuberculous deposit; the outer coat is rough and nodulated; the mucous lining is ulcerated and often presents vegetations and polypi of a granulomatous type; the mass is firm, but not hard to the touch. The neighbouring mesentery is occupied by enlarged glands, and these may also be found on the inner border of the ascending colon. Adhesions may be present, and lead to kinking or twisting of loops of bowel, which may assist in producing intestinal obstruction. The symptoms vary a good deal, but in the early stages constipation and diarrhœa may alternate, whilst later on obstructive phenomena may supervene, or even well-marked pyrexia of a hectic type. The diagnosis from a cæcal carcinoma is not always easy; the chief points in favour of tubercle are the earlier age (under forty years), the longer duration of symptoms (two or three years), the associated pyrexia, and the presence of tuberculous lesions elsewhere. The diagnosis is, however, not uncommonly made on the operating-table. *Treatment* consists in short circuiting, or excising the mass. The latter may involve an extensive procedure, but even when enlarged glands have to be left behind, the case may do well.

Stenosis of the Intestine arises from two main causes—the contraction of cicatrices or adhesions, and the development of tumours, usually malignant.

Simple or **cicatricial** stricture usually results (1) from the healing of ulcers which have extended more or less circularly around the bowel, or have involved its walls extensively. Hence, tuberculous ulcers lend themselves to its development more than the typhoid lesion, and it is a little doubtful whether it has ever occurred as a sequela of the latter. Syphilitic ulceration is followed by it, especially when involving the rectum; but the upper part of the jejunum is also occasionally affected. In the large intestine dysentery is the most common cause, and the stenosis, like the ulceration, may be irregular and extensive. (2) It may follow strangulated hernia as the result of ulceration along the actual site of constriction; and, similarly, it may develop after the separation of an intussusception. (3) An end-to-end anastomosis of the gut may lead to stenosis unless considerable care is taken not to tuck in too much of the gut wall. (4) The contraction of adhesions outside the intestine is by no means an uncommon cause; thus it may be due to many forms of localized peritonitis, and frequently ensues after pelvic cellulitis.

Owing to the contents of the *small* intestine being of a somewhat liquid nature, a stricture in this situation often exists for some time before symptoms of any urgency arise. The patient may complain of a certain amount of indigestion and discomfort, but sooner or later the narrowed aperture of the gut becomes blocked either by a fold of mucous membrane or by a portion of undigested food, and thus an attack of obstruction is induced. In the early stages of the disease this can be overcome and remedied by purgatives, but each recurrence is likely to increase in severity, until finally an acute attack supervenes, which kills the patient, unless relieved by prompt surgical interference.

In the *large* intestine very similar phenomena appear, but the attacks of obstruction are of a somewhat different character, since there is less pain and vomiting; and aperients, instead of relieving the patient, as they often do in the earlier attacks in the small gut, always aggravate the symptoms; there is also much greater distension of the abdomen. The diagnosis of stricture, though strongly suggested by the symptoms, can only be confirmed absolutely by an exploratory operation, except when the lower part of the rectum is involved.

The **Treatment** in the earlier stages consists of suitable dieting, and the administration of purgatives or of large enemata, and for a time such will be successful. Sooner or later, however, a more than usually serious attack of obstruction will call for something more radical, and readers are referred to the chapter on obstruction for details of the treatment to be adopted. Apart from the question of obstruction, a stricture of the small intestine is to be treated by enteroplasty or enterectomy. For stricture of the cæcum or ascending colon, some short-circuiting method, whereby the ileum is implanted into the colon below the stricture (ileo-colostomy), is perhaps the best plan to adopt; in the transverse colon excision is possible, as also in the sigmoid flexure. Failing any of these measures, the establishment of an artificial anus will be required to give relief. It must be remembered, however, that no permanent opening of this nature can be permitted in the small intestine since the absorption of nourishment is thereby so interfered with that death from asthenia is certain to follow in a comparatively short time, whilst the intestinal contents are fluid and extremely irritating to the skin.

Tumours of the Intestinal Wall may be simple or malignant, primary or secondary. *Simple* tumours are unusual, and consist of papilloma, adenoma, myoma, lipoma, and a few other varieties. They may cause irritation and irregular action of the gut, resulting perchance in intussusception (p. 1136); hæmorrhage, sometimes of a serious character, is associated with multiple papilloma or adenoma; and obstruction occasionally ensues. It is unusual for a diagnosis to be made apart from an exploratory laparotomy, unless the rectum is affected. The *treatment* is governed by the location of the growth and by the symptoms it causes.

Sarcoma of the intestine is not common; it may involve the ileum or cæcum, and give rise to a localized tumour or diffuse infiltration. Obstruction may ensue, or considerable peritoneal irritation resulting in an abundant blood-stained exudation which leads to abdominal distension, and may be recognised as due to a new growth on tapping. Treatment consists in removal of the affected coil of gut if the disease has not progressed too far.

Cancer of the Bowel is almost always primary in nature, and is then usually a columnar carcinoma, to which colloid degeneration is sometimes added. The small intestine is rarely involved, but any part of the colon may be affected, and even the vermiform appendix. Secondary growths are occasionally met with, and are necessarily of the same nature as the original tumour. The physical characters of the growth vary considerably.but usually conform to one of two types—viz., (i.) the *hypertrophic*, in which a large mass forms, perhaps occupying the whole lumen of the bowel (Fig. 485). It is a fairly rapid growth, and usually associated with ulceration and hæmorrhage, whilst obstructive phenomena are late in appearing. (ii.) In the *sclerosing* form the tumour develops as an annular constriction around the bowel, the lumen of which is contracted so that it may be almost impossible to pass a crow's quill or a probe through it (Fig. 486). It is an astonishing feature of these cases that the function of the bowel is carried on without much pain or difficulty until the lumen is almost obliterated, and then suddenly a serious attack of obstruction occurs. Sometimes the bowel looks from outside as if a piece of string had been tied round it, so great is the constriction. Above the growth the bowel is hypertrophied and dilated; the mucous membrane is often congested, inflamed, and even ulcerated; the latter lesion is usually due to the irritation of stagnant fæces, and the ulcers are termed 'stercoral.' Bacteria may find their way into and through the intestinal wall from these foci, and lead to peri-intestinal suppuration, and as a sequela a fæcal fistula may develop. The bowel below the growth is often distended ('ballooned') from paralysis of its walls, and the development of gases from the fæcal material which may accumulate from the loss of the *vis a tergo ;* this can often be remarked in cancer of the rectum.

The irritation of the tumour leads sooner or later to the formation of adhesions, which may assist in hampering the action of the bowel. Secondary deposits occur in the mesenteric glands and omentum, and less commonly in the liver or distant regions; but there can be no question that the growth is often much less malignant in type than cancer elsewhere, and both adhesions and secondary deposits are usually late developments. On the other hand, there is a considerable degree of permeation by cancer cells, and this over an area so extensive that it is useless to undertake removal of merely the affected portion of the bowel; a wide and extensive excision will alone suffice to cure.

The **Symptoms** are at first vague in the extreme, and the disease is likely to have progressed for some time before a diagnosis is reached. The patient complains of indigestion of an intestinal type; there may be some pain of a colicky character, and either constipation or diarrhœa may be present; not unfrequently they alternate, the constipation being primary, and the diarrhœa resulting from the decomposition of retained fæces, or a catarrhal enteritis set up thereby. A discharge of mucus or blood may be noticed in the stools, and the patient's nutrition begins to suffer, although wasting is at first slow.

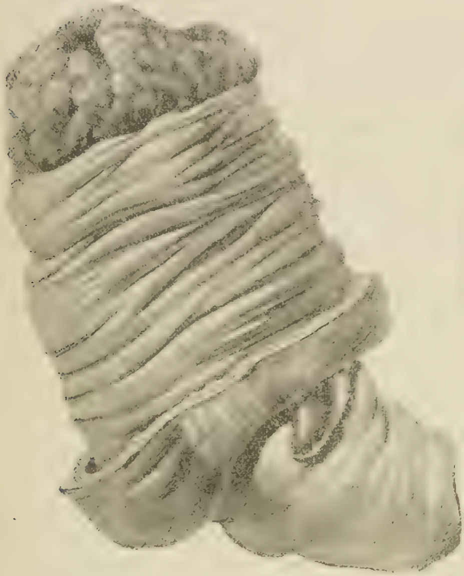

FIG. 485.—HYPERTROPHIC CANCER OF THE CÆCUM, INVAGINATED INTO THE TRANSVERSE COLON.

For bismuth radiograph of this case see Fig. 483. This growth was successfully removed, and an ileocolostomy performed.

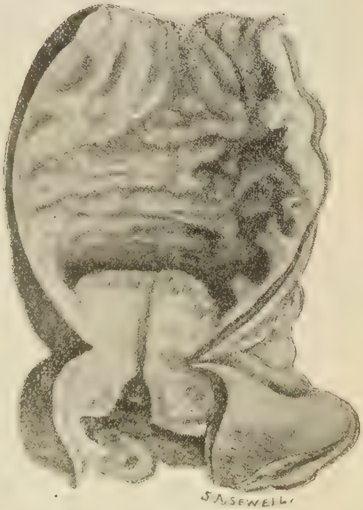

FIG. 486.—CARCINOMA OF THE DESCENDING COLON.

The growth was of the sclerosing type, and had given rise to no symptoms except a little diarrhœa until the onset of a fatal attack of obstruction.

The conditions which may require and justify interference by the surgeon are as follows: (1) Repeated attacks of slight obstruction, especially if localized resistance of the abdominal wall or an indefinite sense of fulness in some region is associated therewith; (2) an acute attack of obstruction, the nature and symptoms of which vary with the site of the lesion; (3) the existence of a tumour, which, though at first readily moveable, becomes fixed after a while, owing to the formation of adhesions; and (4) the development of a peri-intestinal abscess. On the other hand, if it is evident that secondary deposits are present in the omentum or elsewhere, and the primary growth is so large or fixed that its removal is doubtful, it is useless to undertake merely an exploratory operation. In these cases it will suffice to interfere when obstructive phenomena make their appearance. The mere handling of such a growth, the inner surface of which is probably ulcerated, is sometimes sufficient to determine increased activity of the bacteria, and the development of an abscess around the growth, which may be followed by diffuse or localized peritonitis, and even by a fæcal fistula.

The importance of an early **Diagnosis** cannot be over-estimated; every case of irregular intestinal function, especially if associated with pain, should be carefully investigated by abdominal palpation, and if need be by bismuth radiography. Sigmoidoscopy is also of value in examining the lowest 10 or 12 inches of the bowel.

Treatment.—Unfortunately, cases are usually left until the progress of the disease has settled the question of diagnosis, and then palliative treatment may alone be possible. If found early enough, a radical operation for removal of the growth may be undertaken, and the intestinal canal restored by enterorrhaphy. Affected mesenteric glands are included in the part excised, if possible, but the total removal of the growth is quite justifiable, even if glands have to be left, inasmuch as it restores the functional activity of the tube. It must be remembered, however, that unless the bowel has been thoroughly emptied previously it is always wiser to make a temporary artificial anus, and restore the continuity of the canal at a later date. Hence excision should never be undertaken when obstruction is present.

Cancer of the cæcum requires removal of the lower inch or two of the ileum, as well as of the cæcum and a varying portion of the ascending colon (possibly, for choice, the whole), in order to include the lymphatic area; the ileum is then united to the transverse colon. In cancer of the ascending colon or hepatic flexure, the excision must extend well into the transverse, and it is then easier to include the cæcum in the scope of the excision and unite the ileum to the transverse colon than to leave it behind. Cancer of the transverse colon must be removed with a free hand, and then, by 'mobilizing' (p. 1038) the ascending and descending portions of the colon, it may be possible to anastomose them effectively; failing this, an ileo-sigmoidostomy must be performed. Cancer of the splenic flexure is often difficult to remove because of its greater fixation, but when practicable must include the left half of the transverse colon and a portion of the descending colon. The continuity of the intestinal canal is restored by uniting the proximal end of the transverse to the iliac colon, or by performing an ileo-sigmoidostomy. Cancer of the iliac colon involves removal of the greater part of the descending colon with it, and the union of the transverse colon to the pelvic colon or rectum; in some cases it is wiser to perform an iliac colostomy, and remove completely the segment of bowel below it. The same practice holds good for many cases of cancer of the pelvic colon or upper end of the rectum, where it is impossible to restore the continuity of the canal.

Should excision be impracticable, owing to the extent or fixity of the tumour, the following plans of treatment may be considered, and that which best suits the requirements of the particular case undertaken.

1. The growth may be *short-circuited* by uniting portions of gut above and below it. This is usually accomplished by one of the forms of lateral anastomosis described hereafter; thus, the cæcum may be attached to the sigmoid flexure in a case of cancer of the transverse colon.

2. The bowel may be entirely divided above the tumour, and the upper end implanted into the gut below it, the lower end of the divided bowel being closed (Fig. 487). This *lateral implantation* is the best plan of treatment to employ for cancer of the cæcum which cannot be extirpated; the ileum is divided above the valve, and its upper end implanted into the ascending or transverse colon well beyond the growth (ileo-colostomy), whilst the lower end is totally closed.

3. The affected coil of gut has been *excluded* from the intestinal tube by dividing the bowel above and below, and uniting the upper and lower segments. One end of the diseased coil is closed, and the other is brought to the surface and fixed there so as to establish a fistulous track. There is always a certain amount of discharge from the cancerous growth, and the mucous membrane itself secretes, so that total closure of the excluded loop would be accompanied by danger.

4. Finally, if none of these measures are applicable, or if the patient's condition is such as to make it unwise to attempt them, and if the growth is situated in the colon, an artificial anus may be established.

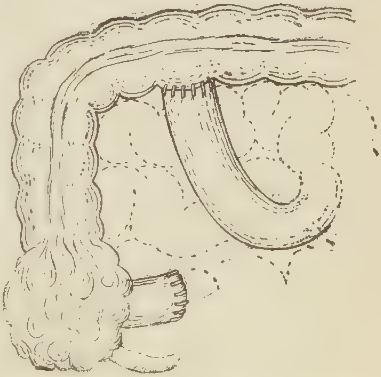

FIG. 487.—LATERAL IMPLANTATION OF DIVIDED END OF ILEUM INTO THE TRANSVERSE COLON FOR IRREMOVEABLE CANCER OF THE CÆCUM (ILEO-COLOSTOMY).

Idiopathic Dilatation of the Colon (Hirschsprung's disease) is a rare affection met with in infancy, but occasionally lasting on till young adult life. The cause in many cases is unknown, but congenital contraction of the rectum has been found in some. It is characterized by enormous distension of the colon, and usually of the sigmoid flexure; possibly on opening the abdomen nothing but the colon is seen. The walls are hypertrophied, and stercoral ulcers may be present. The abdomen is distended, but soft and free from rigidity; the child does not complain of pain and tenderness, and vomiting is unusual. The most prominent symptom is constipation, and that generally of a most obstinate character, purgatives having no effect but to cause pain and vomiting. Enemata are often retained, and even gas cannot easily be passed; the introduction of a long flatus-tube is followed by the escape of very putrid gas in large quantities. Death results from cachexia, perforative peritonitis, or obstruction. **Treatment.**—Purgatives must be avoided, but massage and electricity may do good, together with the routine use of enemata. Excision of the distended portion, followed by a lateral anastomosis, is probably the best surgical treatment. In one case, operated on by Sir F. Treves, excision of the rectum, sigmoid flexure, and descending colon was performed, and the transverse colon was dragged down and fixed in the perineal opening.

Enteroptosis, or Glenard's disease, is a condition not uncommonly met with in which there is a general displacement downwards of the viscera. The small intestine, transverse colon, kidneys, and stomach are the organs chiefly involved, but any of the viscera may be affected. The cause varies and cannot always be ascertained; sometimes it commences after an acute illness, more usually it is chronic and develops gradually. The relaxed abdominal wall which follows repeated pregnancies is often present, and tight-lacing may be an important causative factor. Women are much more frequently affected than men. The condition *per se* is not necessarily associated with symptoms, but in a considerable number of cases marked neurasthenia is present, possibly from the drag of the viscera upon the sympathetic plexuses in the posterior abdominal wall. The amount of displacement is no measure of the severity of the symptoms. The stomach may be well below the costal arch, and when inflated stands out prominently, both curvatures being visible; it is usually distended atonically, and succussion sounds may be heard. The relaxation of the small intestines is alluded to in connection with the ætiology of hernia (p. 1086). The transverse colon may sag downwards into the pelvis, and the kinking of the splenic and hepatic flexures thereby induced may be an important element in the production of constipation. For bismuth radiograph of prolapsed transverse colon, see p. 1015. The spleen and liver may also slip downwards. Displacement of the kidneys is referred to under the heading ' Moveable Kidney.'

Treatment must be wisely modified according to circumstances, and due allowance made for the neurasthenic element. A course of Weir Mitchell treatment (*i.e.*, rest and feeding) is often valuable, both for its influence on the nervous state and also in assisting to increase the deposit of fat. Electricity and massage to the abdominal walls, together with suitable gymnastic exercises, help to restore their tone and to improve the condition of the underlying viscera. An abdominal belt or bandage will do much to relieve symptoms, especially if applied with the patient in the Trendelenburg position. Operation is not to be lightly undertaken; but if a fair test has been given to the above measures, it may be justifiable to open the abdomen and stitch up into place organs like the stomach, liver, or spleen, or to brace up the abdominal wall by some plastic operation, such as that suggested on p. 1109. For treatment of moveable kidney, see p. 1190. The question of removing or short-circuiting the kinked colon may also have to be considered.

Intestinal Stasis is a term recently introduced to indicate a condition of abnormal delay of the bowel contents in some part of the intestinal canal, especially the colon. This delay allows marked putrefactive changes to occur, and in consequence abnormal absorption of toxins, which, circulating in the blood-stream, produce not only a general depreciation of health, but also considerable degenerative changes in many of the viscera and tissues. Sir Arbuthnot Lane has done most excellent work in emphasizing the character and dangers of this condition, although his theories and conclusions are not generally accepted by all surgeons. He attributes the whole range of phenomena to the assumption by man of the erect attitude and the natural consequential tendency of the intestines to drop. To counteract this, a reactive formation of peritoneal bands and membranes occurs, producing results more or less similar to those following peritonitis, and attaching the intestines to parietal structures. Thus to the outer side of the ascending colon one often finds a set of membranous bands running downwards and inwards from the parietal peritoneum to lap over the intestine and be attached to the front of the ascending meso-colon; this thin vascular veil is sometimes termed *Jackson's membrane*, and if at all exaggerated may cause interference with the activity of the colon. At the hepatic and splenic flexures similar developments occur, and may cause such contractions as to kink the gut severely. Even more importance is attached by Lane to a band of adhesions running from under the surface of the mesentery to the anti-mesenteric border of the ileum, a few inches from the cæcum; the contraction of this band causes a kink at the termination of the ileum (*Lane's ileal kink*), and thus determines retention of the ileal contents. The result of this is increased sagging of the small intestine in the pelvis and dragging on the duodeno-jejunal flexure; this is stated to cause a reactive formation of bands, which first support the flexure, but, if excessive, subsequently kink it, causing dilatation of the stomach and duodenum. Similar bands and kinks are described elsewhere. The whole series of phenomena is looked on as mechanical and reactive, and not of an inflammatory nature, although structures, such as the appendix or gall-bladder, are often involved in the adhesions. This view of the condition is not universally accepted; many surgeons look on the bands as the result of inflammatory attacks, and Professor Arthur Keith has shown that many of them are of congenital origin and due to an exaggeration of the ante-natal plastic peritonitis which fixes the colon in its place. The subject, however, is too large to discuss here, and opinions at present too divided to allow of dogmatization.*

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* For further details, see Report on Discussion on Intestinal Stasis, Royal Society of Medicine, vol. vi., Nos. 5 and 7 (Supplements).

The **Symptoms** arising from intestinal stasis are threefold: (i.) *Mechanical* results follow from distension of various portions of the intestinal canal—*e.g.*, the stomach, duodenum, ileum, or colon Most of these have been alluded to already, but one would especially emphasize the troubles that arise from prolapse of the colon into the pelvis, which can be readily demonstrated by bismuth radiography (Fig. 482). The colon becomes filled with liquid fæcal material which cannot be passed on. (ii.) *Inflammatory* phenomena of various types follow this stasis—*e.g.*, gastric and duodenal ulceration, appendicitis, colitis, etc. (iii.) *Toxic* results necessarily ensue, and include such conditions as enfeebled circulation, cold sweating, cyanosed extremities, facial pigmentation, muscular weakness, with various nervous and perhaps mental perturbations. The resistance of the individual to bacterial invasion is also lowered, and sundry infective diseases may supervene.

Treatment.—Early and mild cases can often be treated effectively by improving the tone of the abdominal wall and increasing the motor power of the colon by a course of abdominal massage and suitable gymnastic exercises. Purgatives, intestinal antiseptics (such as liquid paraffin), careful attention to diet, and a sufficiency of rest in the recumbent posture, will do good; a relaxed abdominal wall, of course, requires suitable external support or some operative treatment to tighten it up. In the worst cases, where the cæcum and transverse colon sag into the pelvis and have become literally transformed into cesspools filled with putrid fæcal material, ileo-colostomy or -sigmoidostomy, with or without an extensive colectomy, according to the extent and gravity of the case, may be the only practicable treatment that holds out any prospect of amelioration; but it must not be undertaken unnecessarily, as sometimes the result is a persistent diarrhœa, owing to the loss of the colon, which acts largely as a drying-ground for the fæces. See also on treatment of Enteroptosis (p. 1028).

Operations on the Intestines.

1. **Enterotomy** is a term which is only correctly applied to an incision made into the intestine either for the removal of a foreign body or for the examination of its interior. The wound should always be placed in the longitudinal axis of the gut, and along its anti-mesenteric border; it is closed by a row of Lembert, Czerny-Lembert, or Halstead stitches.

2. **Enterostomy,** or the formation of an artificial opening into the bowel, may be undertaken for several reasons, and any part of the gut may be opened. (*a*) The jejunum may be brought to the surface and opened (*jejunostomy*) in cases of cancer of the stomach where gastro-enterostomy and pylorectomy are impossible and the patient is dying of inanition; he can subsequently be fed by the fistula in this way produced. (*b*) The ileum may need to be opened, and drained in cases of obstruction not lower than the cæcum or ascend-

ing colon, when the small gut is much distended and the patient's general condition so bad that no prolonged search for the cause and no attempt to deal directly with it, even if obvious, are possible. The abdomen is opened either in the middle line or in the right iliac region; a suitable distended coil is withdrawn and opened after carefully protecting the peritoneal cavity from fæcal infection. A large trocar and cannula are first introduced, so as to allow the first gush of flatus and fluid contents of the gut to escape; the opening is then enlarged and a rubber drainage-tube stitched in, or a Paul's (glass) tube tied in (Fig. 488) by means of a purse-string suture passing in and out through the whole thickness of the bowel wall, and the affected coil of intestine fixed to the abdominal wall. A thin tube of rubber is attached to the other end of the glass tube, and through this the intestinal contents are temporarily allowed to escape without contamination of the peritoneal cavity or of the wound

If the patient recovers from the acute symptoms, a second operation will be needed in order to re-establish the continuity of the intestinal canal. Life is not likely to be of long duration if an artificial opening exists above the cæcum, as the exclusion of the absorbing mucous surface of the large intestine seriously hampers nutrition. The fluid contents of the small intestine also act as a serious irritant to the skin of the abdominal wall.

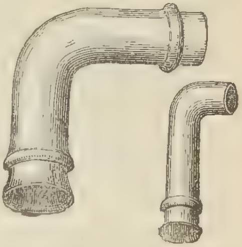
FIG. 488.—PAUL'S TUBES (GLASS), LARGE AND SMALL SIZES.

(c) **Colostomy,** or, as it is more usually termed, 'colotomy,' is frequently employed in dealing with diseases of the lower bowel, and is an extremely successful proceeding.

The character of the artificial opening varies considerably according to whether or not it is intended to be a permanent condition. If merely a temporary opening is required, the smaller the portion of bowel secured to the parietes the better, since the subsequent operation for its closure is so much simpler (Fig. 489). But where a permanent aperture has to be established, the surgeon's aim should be to divert totally the course of the fæces; and hence it is desirable to withdraw a portion of the gut from the abdominal cavity, and to cut away a complete segment, including also, if possible, a portion of the mesentery. By this means the upper and lower openings are brought to the surface of the skin, and separated from one another by an area of cicatricial tissue representing the section of the mesentery (Fig. 490).

The **ascending colon,** or preferably the *cæcum,* is occasionally opened in cases of membranous or ulcerative colitis where there is an abundant secretion of pus, and the patient's life is threatened by pyrexia and toxic exhaustion. The object of the operation is two-fold—viz., to prevent the irritation caused by the passage of the fæces over the ulcerated mucous membrane, and to permit the colon to be irrigated. Inasmuch as the contents of the bowel at this level are fluid and very irritating, it is wise to make the opening as small as possible, and this may be done by stitching firmly into the bowel a piece of rubber drainage-tube as in Witzel's operation for gastrostomy (p. 1007) and then fixing the bowel to the skin and abdominal muscles. It is possible, however, that in spite of every precaution the skin will become inflamed. If the opening has to remain for some time, the patient must be provided with an abdominal belt to which is fitted an elastic pad carrying a solid rubber plug which fits into the aperture.

Intestinal obstruction at the hepatic flexure sometimes necessitates a cæcal colostomy, which is performed as for the small intestines, a Paul's tube being tied in. A secondary operation is usually required in order to excise the cause of the obstruction, or to short-circuit it.

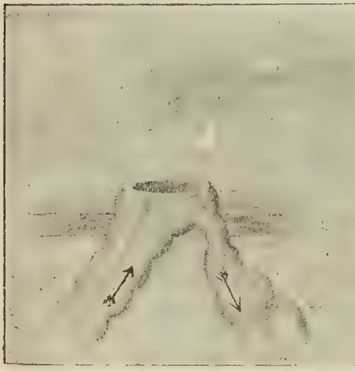

FIG. 489.—DIAGRAM OF TEMPORARY COLOSTOMY, SHOWING THE SINGLE OPENING ON A LEVEL WITH THE SKIN, THE PASSAGE TO THE LOWER BOWEL BEING MERELY BLOCKED BY A SPUR OF MUCOUS MEMBRANE.

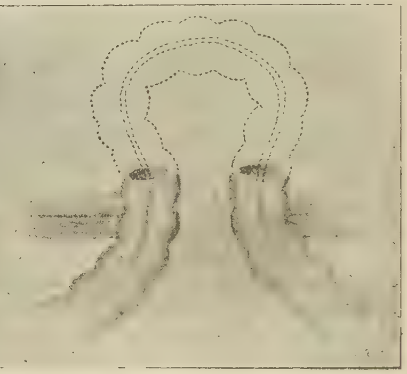

FIG. 490.—DIAGRAM OF PERMANENT COLOSTOMY, SHOWING THE TWO OPENINGS SEPARATED ONE FROM THE OTHER BY A SECTION OF THE MESENTERY.

The **transverse colon** is most likely to need to be opened for an obstruction located in the splenic flexure, as by carcinoma or adhesions. In all probability the source of the trouble has not been recognised prior to operation; the abdomen is explored through an incision in the middle line, and in order to relieve the urgent symptoms the distended transverse colon has to be opened at once and a Paul's tube tied in. If the case is less urgent, and yet a considerable amount of fæcal material is present in the gut, a small portion should be stitched to the surface, and after adhesions have formed, it may be opened and drained for a few days. Necessarily the situation is not a desirable one for an artificial anus, and therefore it should be only of a temporary character. When the bowel has been satisfactorily emptied, the abdomen should be again opened, and some form of anastomosis performed to short-circuit the obstruction if excision of the growth is impossible.

The **descending colon** or **sigmoid flexure** is the most frequent situation for colostomy. Two chief methods have been employed—viz., the *lumbar* operation, in which the upper part of the descending colon is reached behind or through the peritoneum, and the *iliac*, in which the upper part of the sigmoid flexure or lower end of the descending colon is brought to the surface after opening the peritoneal cavity.

Uses of Left Lumbar or Iliac **Colostomy.**—The operation is required under the following conditions: (1) For congenital absence of the rectum, when a perineal incision has failed to discover it; (2) for chronic obstruction of the lower end of the large intestine, which cannot be relieved by enemata or medical means, such as that arising from simple or malignant stricture, or from the pressure of pelvic tumours; (3) for carcinoma of the rectum or sigmoid flexure, whether obstruction is present or not, if a radical operation is impracticable, or as a preliminary to excision; (4) for some cases of syphilitic, tuberculous, and other forms of ulceration of the rectum, which cannot heal as long as they are irritated by the passage of fæces; (5) for irremediable cases of recto-vesical and recto-vaginal fistula, whatever their origin; (6) for volvulus of the sigmoid flexure, the iliac operation being needed not only to relieve the obstruction, but also to prevent recurrence.

Left Lumbar Colostomy (**Amussat's Operation**) has been much neglected of recent years, and practically replaced by its iliac rival. Performed as it was in the old days without opening the peritoneal cavity, this operation was certainly not a desirable one; but if the method described below is adopted, it will probably be found as efficient as the iliac proceeding. The patient lies on the right side, with a sandbag beneath the loin, so as to increase the space between the last rib and the crest of the ilium. The position of the colon is indicated by a vertical line drawn upwards from a point ½ inch behind the centre of another line, passing from the anterior to the posterior superior iliac spine.

The centre of the incision should correspond to this line midway between the last rib and the crest of the ilium. It should be made parallel to the last rib, and for practical purposes may commence at the outer border of the erector spinæ, and pass outwards for about 4 or 5 inches (Fig. 534, A, p. 1175). This incision is carried through the layers of the abdominal muscles and the fascia lumborum, and opens up the loose fatty subperitoneal tissue.

If the gut is distended, it may at once come into view; but if collapsed, it is not recognised at first. In about 20 to 30 per cent. of individuals a true peritoneal descending meso-colon is present. Under any circumstances the peritoneum is opened in the anterior portion of the wound, and the colon definitely looked for and identified. The highest portion that can be reached is secured, so that there shall be no slack intestine above the opening to give rise later on to prolapse; for choice, one fixes the end of the transverse colon to the skin.

If the case is not urgent, the loop of bowel is withdrawn and secured to the skin by sutures through the sero-muscular coats; the rest of the parietal incision is closed. After a few days the bowel is opened. It is well to fix it as far back in the wound as possible, so as not to leave a pocket behind in which discharges can accumulate. If, however, urgent obstruction is present, requiring immediate relief, the bowel is drawn out of the wound and opened with the same precautions as in the iliac procedure. A trocar and cannula is introduced to give exit to the first gush of flatus and fluid fæcal matter, and then a Paul's tube is tied in, the bowel stitched to the skin, and the rest of the wound closed.

Lumbar colostomy is not much in favour at the present day, but there are surgeons who maintain that in reality a lumbar opening is more comfortable and convenient than one in the iliac fossa, and that it is much easier to control the escape of fæces than in the latter proceeding.

Iliac Colostomy, or Littré's Operation, consists in opening the lower portion of the colon or sigmoid flexure through the anterior abdominal wall. Various incisions are used; some surgeons employ a vertical incision through the outer fibres of the rectus muscle in the hope of gaining some measure of sphincteric control. Others employ an incision 2 or 3 inches in length, made at right angles to a line extending from the anterior superior spine to the umbilicus, the centre of the incision corresponding to the junction of the outer and middle thirds (Fig. 473, D). The abdominal parietes are divided, either in the line of the cutaneous incision, or by McBurney's method of splitting the muscles in the line of the fibres; the latter is only desirable when there is but little distension, and when it is not necessary to make an extensive exploration of the viscera. The sigmoid flexure is sought for, and recognised by the presence of the appendices epiploicæ and the longitudinal bands of muscle fibres. It is gently drawn out, and the upper part is selected for fixation in the wound, so as to diminish the risk of subsequent prolapse. Many different plans of *fixation* are in vogue. (i.) Undoubtedly the best, if possible, is to make an opening through the meso-colon, and through this to draw together the segments of the abdominal wall by suitable deep stitches and superficial sutures in the skin (Fig. 491). The possibility of undertaking this operation depends on the degree of laxity of the sigmoid flexure; where the meso-colon is short, the peritoneum to its outer side should be freely divided, and the colon 'mobilized' inwards to a sufficient extent to enable this type of operation to be undertaken. (ii.) If, in spite of its mobilization, it is not very free, it is better to make a hole through it and to introduce a glass rod which, resting on the abdominal wall on either side, supports the gut until suitable adhesions have formed. It is wise to pass one stitch through the skin at each end of the rod and tie the latter securely to it, so as to prevent the risk of it slipping aside. (iii.) A useful and effective method of fixation is to pass a mattress suture of strong silk through the parietes (including the skin, muscles, and peritoneum) on either side, the stitch traversing the meso colon *en route* (Fig. 492). By tying the ends together, the parietes are brought into close apposition with the meso-colon In all cases a few additional stitches should be inserted, uniting the skin to the longitudinal muscular bands at each end of the incision, and the ends of the parietal wound itself should be closed as much as possible, so as to prevent subsequent prolapse.

If the bowel does not need to be opened at once, it is covered with purified protective, and a dressing is applied. At the end of two or three days the gut is usually opened, and a glass or rubber tube stitched or tied in; no anæsthetic is required for this. At the end of three or four days these tubes become loose, and by the end of a week it is wise to 'trim up' the bowel, removing any unnecessary redundancy, and separating completely the upper and lower ends

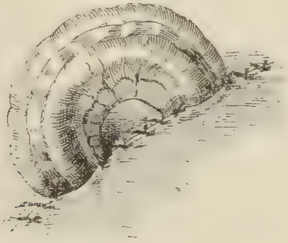

FIG. 491.—ILIAC COLOSTOMY FIXED BY SUTURING ABDOMINAL WALL THROUGH AN OPENING IN THE MESO-SIGMOID.

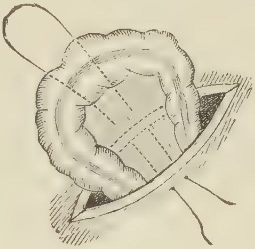

FIG. 492.—ILIAC COLOSTOMY TO SHOW FIXATION STITCH PASSING THROUGH MESENTERY AND ABDOMINAL PARIETES.

Should it be necessary to open the gut at the time of the first operation, precautions similar to those already suggested for enterostomy must be taken in order to prevent the peritoneum from being defiled.

When cicatrization of the wound is complete, a protective apparatus is required in order to keep the patient clean. This should consist of a hollow oval cup, made of plated metal, vulcanite, or celluloid, with a rolled edge, and kept in position either by a truss spring or an abdominal belt. This hollow cup should be large enough to include a 2-inch margin of skin all round the opening, and in the concavity a small portion of antiseptic dressing is placed. Such an apparatus enables the patient to go about in comparative comfort; the bowels are encouraged to act thoroughly every morning by means of an enema, so that no further disturbance need occur during the day.

Comparison of the Two Operations.—At the present time the methodical and deliberate opening of the peritoneal cavity obviates nearly all the difficulties which were formerly experienced in conlater on to prolapse; for choice, one fixes the end of the transverse colon to the skin.

If the case is not urgent, the loop of bowel is withdrawn and secured to the skin by sutures through the sero-muscular coats; the rest of the parietal incision is closed. After a few days the bowel is opened. It is well to fix it as far back in the wound as possible, so as not to leave a pocket behind in which discharges can accumulate. If, however, urgent obstruction is present, requiring immediate relief, the bowel is drawn out of the wound and opened with the same precautions as in the iliac procedure. A trocar and cannula is introduced to give exit to the first gush of flatus and fluid fæcal matter, and then a Paul's tube is tied in, the bowel stitched to the skin, and the rest of the wound closed.

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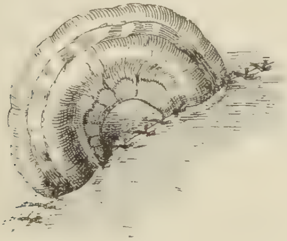

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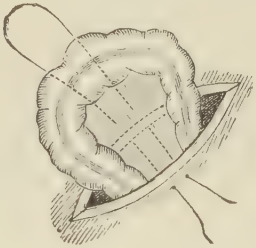

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Comparison of the Two Operations.—At the present time the methodical and deliberate opening of the peritoneal cavity obviates nearly all the difficulties which were formerly experienced in con-

Lembert or Cushing type. Extreme care must be taken in dealing with the mesenteric attachment, as the peritoneal coats separate there in order to enclose the bowel, and the muscular coat retracts considerably; leakage is more likely to occur at this point than at any other.

Some surgeons advise that the first row of stitches should include the whole thickness of the gut, and that the second row should be of the Lembert type. This is unnecessary and undesirable as a routine procedure, as it involves too great an infolding of the gut wall, and thereby the lumen at the site of anastomosis is unduly encroached on, and some amount of stenosis may result.

B. A vast amount of ingenuity has been expended in the production of a variety of *bobbins* and *buttons*, with the idea of facilitating entero-anastomosis and making it safer, but they have been almost entirely discarded at the present day in favour of simple suturing.

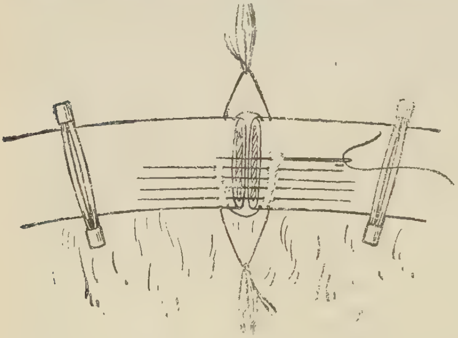


FIG. 493.—END-TO-END ANASTOMOSIS BY SIMPLE SUTURING.

For clearness' sake, the first row of stitches in the mucous membrane has been omitted, and the sero-muscular sutures of the Lembert type are represented as interrupted. In practice one would use a continuous stitch.

5. **Colectomy,** or excision of a larger or smaller portion of the large intestine, is not quite so simple a matter as removal of a part of the small bowel, owing to the greater complexity of the peritoneal reflections and its less mobility. The latter difficulty can, however, be largely overcome, and the colon freely 'mobilized,' by dividing the peritoneal attachments on the outer sides of both ascending and descending colon, and by detaching the transverse colon from the under side of the omentum; the varying portions of the bowel can then be freely drawn over to the middle line with the vessels, nerves, etc., being held merely by one layer of peritoneum. By the assistance of this procedure, large portions of the colon can be removed without much danger or difficulty, and union of the upper and lower segments can be readily affected either by end-to-end anastomosis, or preferably by lateral anastomosis, after closing the divided ends. One essential precaution must be observed if success is to be obtained —viz., the colon must be satisfactorily emptied beforehand; in any case of partial or complete obstruction with retention of the fæcal contents a preliminary colostomy must be undertaken.

6. **Lateral Anastomosis** of the intestine is often employed in order to effect the short-circuiting of some malignant growth, or of a

stricture which cannot otherwise be dealt with. It is also used instead of end-to-end anastomosis to unite divided segments of intestine. The open ends are first entirely closed, and to effect this the bowel should be divided by the knife or thermo-cautery between two pairs of powerful clamp-forceps or enterotribes. If these are left *in situ* for a minute or two, the divided end of the bowel will be found effectively sealed, and can be readily invaginated by a row or two of Lembert's sutures. The portions of bowel are now made to overlap, and the actual anastomosis is performed as for gastro-enterostomy (Fig. 494). Robson's or other suitable clamps are applied, and the coils are brought into suitable apposition. Longitudinal incisions are made through the sero-muscular coats, and these are then united on the posterior aspect of the proposed junction. The segments of bowel are then opened, and any fluid or solid contents carefully mopped up and removed. A continuous stitch unites the mucous membrane all round, and finally the external sero-muscular stitch secures the anastomosis. The operation is completed by securing the divided edges of the overlapping segments of the mesentery so as not to leave an aperture through which internal strangulation might occur.

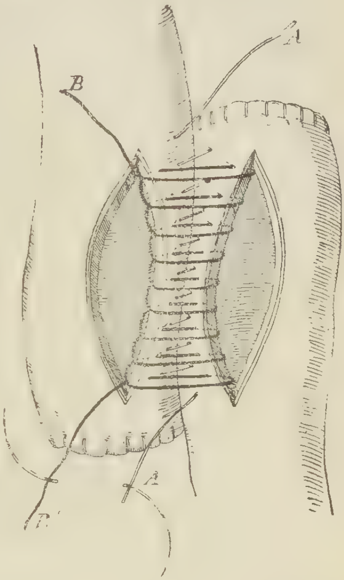


Fig. 494.—Lateral Anastomosis of Bowel after Complete Division.

The divided ends are closed by sutures and approximated by a sero-muscular continuous stitch (A, A′); the incisions in the bowel are then made, and the mucous membranes united by a continuous stitch (B, B′); and, finally, the sero-muscular suture is carried round the whole opening. Only the deep layer of sutures is shown here, and they have not been drawn tight, so as to indicate their relative positions.

7. **Lateral or End-to-Side Implantation** is a procedure not uncommonly required in order to short-circuit a malignant growth (Fig. 487). It is perhaps employed most frequently for irremoveable cancer of the cæcum or ascending colon; the ileum is divided well above the growth; the lower end is closed, and the upper united to the transverse colon. The junction may be made by simple suturing, two rows of stitches being introduced. It is probably wiser, however, to close the end of the ileum and perform a lateral anastomosis, as described above, inasmuch as it is possible thereby to secure a larger opening.

Appendicitis (*Syn.:* Perityphlitis, Epityphlitis, etc.).

Appendicitis is an affection which may appear at any time of life, but it is most common in young adults, and the male sex is more frequently attacked than the female. The disease is sometimes of but slight significance, but occasionally runs such a virulent course as to destroy life in a few hours. Its importance lies in the fact that it is an infective process, and inasmuch as the peritoneal envelope is generally involved, a certain degree of peritonitis is almost necessarily a consequence.

Ætiology.—Many different conditions contribute either directly or indirectly in determining an attack of appendicitis. (1) The appendix is to be looked on, not as an actively functional structure, but as a degenerated relic or remnant, which is apparently of little value or importance. Hence, as in other similar structures, it often has but a poor blood-supply, derived from the posterior ileo-cæcal branch of the ileo-colic artery. The main nutrient vessels traverse or run along the free border of the meso-appendix, but a second twig often runs down the base of the mesentery, and is more or less independent of the others. Some authorities join issue with the above-mentioned view as to the inutility of the appendix, and maintain that it secretes a fluid which stimulates the peristalsis of the cæcum or colon (MacEwen). This may be so, but the fact remains that a vast number of people who have lost their appendixes by operation get on quite well without them. (2) A large amount of lymphoid tissue is present in the mucous membrane, especially in young people, so much, in fact, that the title of ‘ abdominal tonsil ’ has been applied to it. The lymphoid follicles have a tendency to atrophy with advancing age. Inflammatory processes are readily set up within its walls as a result of the absorption of toxins or organisms, which are almost constantly present within it. It is interesting to note here that some look on appendicitis as an outcome of rheumatism, and the association of that disease with tonsillitis is suggestive. (3) Its length and direction vary considerably in different individuals. In length it may measure anything between 1½ and 11 or 12 inches, but is usually 3 to 4 inches long, whilst as to direction, it may lie in any axis, and the clinical picture is largely influenced by its anatomical position (Plate VIII.). The commonest situation is behind the cæcum in relation with the lowest end of the mesentery, pointing towards the spleen; but it is not unusual for it to lie deeply behind the cæcum, pointing down towards the pelvis, and then pelvic complications almost always accompany an attack of appendicitis. At other times the appendix lies to the outer side of the cæcum, and the inflammatory reaction then may be more localized. The position of the appendix also governs the facility with which the intestinal contents find their way into its lumen, and it seems probable that appendicitis is more commonly met with where it is so placed as readily to admit material which is with difficulty expelled—*i.e.*, when it is transverse, or directed downwards. A longer appendix is also more liable to become twisted and kinked on itself. (4) The extent to which the meso-appendix is attached is also an important element, since the portion which projects beyond its free border is less well supplied with blood. As a matter of fact, the mesentery often does not extend beyond the junction of the middle with the distal third, and perforation not unfrequently occurs about this spot. The vessels often run in the free border of the mesentery, and kinking of the appendix may result in thrombosis of the vessels and gangrene. (5) The communication with the cæcum is usually a small one, and is guarded by an insignificant fold of mucous membrane, known as the valve of Gerlach. Sometimes this aperture becomes blocked, or the orifice stenosed, as the result of a preceding attack of typhlitis or inflammation of the mucous lining of the cæcum, so that an accumulation of mucus occurs within the appendix, leading to its dilatation into a cyst-like pouch. (6) The *contents* of the normal appendix consists of a little mucus and a certain number of bacteria, similar to those found in the neighbouring intestine; they do no harm unless the mucous lining is so damaged as to permit them to invade the living tissues, and then they become virulent. A generalized infection of the intestinal canal, perhaps the result of oral sepsis, will obviously be a favourable condition for determining inflammation of the appendix. *Foreign bodies*, such as pips, pins, etc., are occasionally found within it, and by their presence and irritation may light up an attack of appendicitis. They are much less common than was formerly imagined, and the fact that the opening into the intestine is generally not larger than to admit a No. 8 catheter will explain this rarity. *Fæcal concretions* are comparatively common; they are oval bodies, varying from ½ to 1 inch in length, and usually laminated, consisting of dried fæcal material mixed with myriads of bacteria, and perhaps with a pip or foreign body as a nucleus. They are not very hard, and can easily be cut with a knife, or even crushed between the fingers. Occasionally they can be recognised in a radiograph of the pelvis taken for other reasons (Fig. 495). They are sometimes the result of a preceding attack which has left the tube contracted, and thus determined stasis and retention of its contents, which have become inspissated. (7) Appendicitis is not unfrequently associated with a true typhlitis or with a more generalized colitis, probably due to chronic constipation; the continuity of the mucous lining of the cæcum and appendix explains this fact, which must always be taken into consideration in estimating the benefits which may be expected from removal of the appendix in a quiescent stage. Much disappointment in the non-relief of symptoms has arisen from the persistence of a typhlitis or colitis after the appendix has been removed. Dysenteric ulceration may involve the appendix, or lead to stenosis of its orifice, but it is rarely implicated in typhoid fever. (8) *Injury* in the shape of a strain or sudden twist is not unfrequently mentioned as the cause of an outbreak, and probably acts by displacing a long appendix in such a way as to lead to kinking and possibly to obstruction of the nutrient vessels. When a concretion is present, it is easy to understand that the final attack is determined by some traumatism which modifies the vascular conditions around it. When an appendix is filled with muco-pus as a result of stenosis, either at the orifice or in the tube itself, a blow may lead to its rupture and cause an outbreak of fatal peritonitis.

There can be no question as to the greatly increased frequency of appendicitis at the present day, especially amongst those who live in large towns or cities. It is difficult to assign any one cause for this, but possibly many conditions may be at work—*e.g.*, (*a*) dental disease and degeneration, and consequent oral and intestinal sepsis; (*b*) the bolting and non-mastication of meals associated with the hurry and scurry of modern life, leading to chronic irritation of stomach and bowel. (*c*) Chronic constipation is a most important factor. (*d*) The presence of minute foreign bodies in imported corn and other food-supplies, and the chips derived from enamelled cooking utensils have been suggested as causes, but there has been forthcoming no proof of any connection. (*e*) The greatest dietetic change of recent years consists in the increased amount of meat that

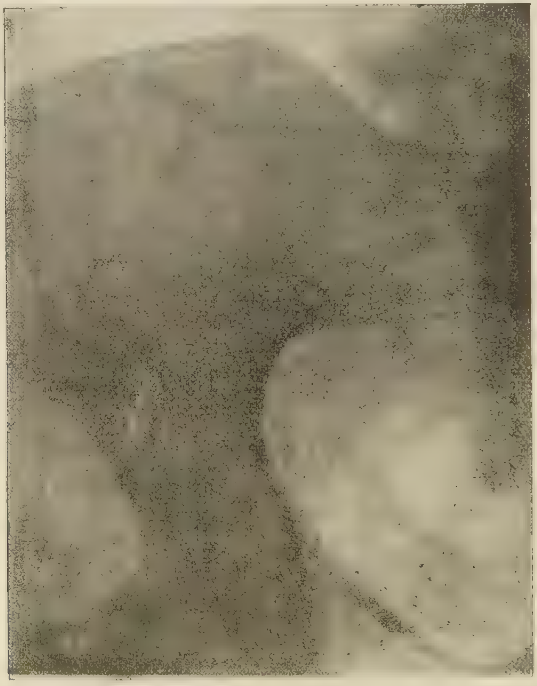
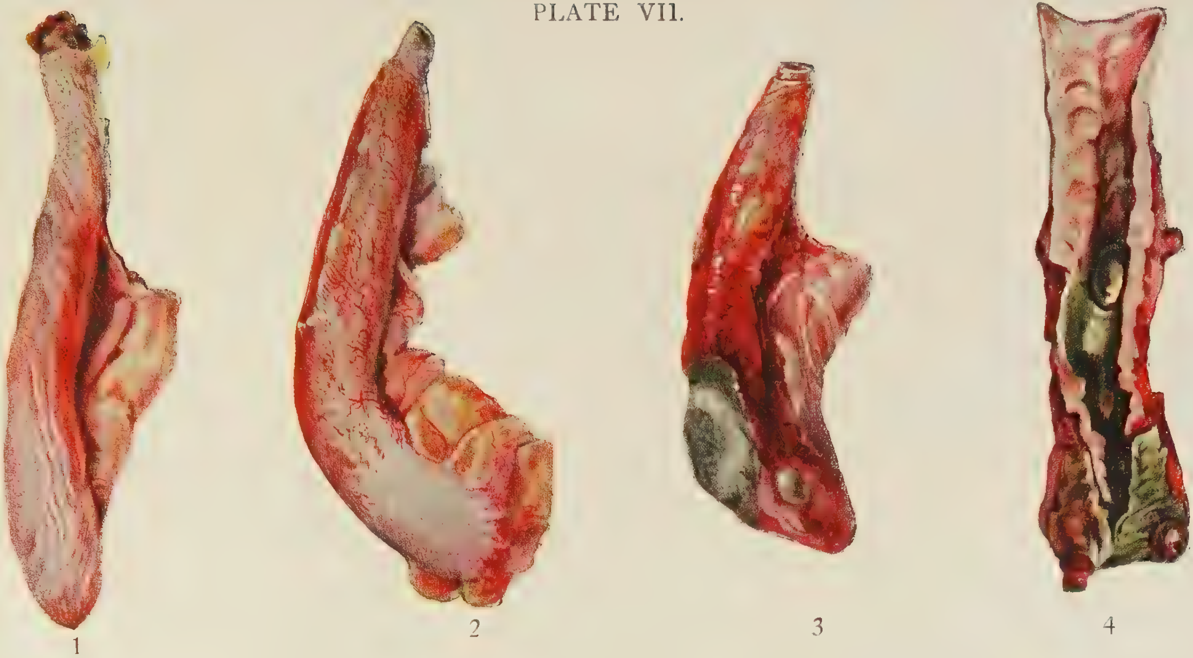


FIG. 495.—RADIOGRAPH OF RIGHT ILIAC FOSSA, SHOWING THE PRESENCE OF AN ELONGATED FÆCAL CONCRETION IN THE APPENDIX. (A. D. REID.)

PLATE VII.



Different types of Appendix after removal for Appendicitis.

Fig. 1.—Catarrhal Appendicitis, some time after an attack which had not quite cleared up, the part being slightly tender on pressure. The appendix is enlarged, and the mucosa on section was thick and congested. *Fig.* 2.—Subacute Appendicitis.—Appendix removed about a week after commencement of an attack, which was not the first. The whole structure was thickened and congested, and at one spot the mucous membrane was thin and nearly perforated. The symptoms had not quieted down satisfactorily. *Fig.* 3.—Gangrenous Appendix which was complicated by an abscess; a perforation is seen near the tip, a little beyond the gangrenous area. *Fig.* 4.—Gangrenous Appendix laid open and showing the presence of a concretion and perforation near the apex.

[*To face page 1042.*

is eaten. The cheapness of imported frozen meat has made it generally available, and it is quite possible that meat which has been frozen for some time is more putrescible than that which is fresh, and hence intestinal sepsis may be favoured. In favour of this idea is the fact that races that live on fish or vegetables are largely immune, whilst members of the same race transported to other regions and put on a meat diet develop the disease.

Pathological Anatomy.—Whatever the assigned cause may be, it must ever be kept in mind that appendicitis is an infective malady, due to invasion of the walls of the appendix by organisms, especially the *Streptococcus pyogenes*, the *B. coli*, and other anaërobic intestinal bacteria. These find an entrance into the wall of the appendix either through an eroded area of the mucous membrane due to the impaction of a foreign body or of a fæcal concretion, or else they are absorbed into the lymphoid tissue so abundantly present, and at once commence to develop and multiply. The results may be best described under the following headings:

(1) **Changes in the Appendix itself.**—These vary considerably in intensity and character according to the cause and the power of resistance of the individual.

In the simpler forms a mere *catarrh* of the appendix results. The organ looks red and swollen, and its peritoneal surface may be smooth, or roughened by loss of endothelium and deposit of lymph. It feels stiff from effusion, and has lost its natural flexibility. The muscular coats are often infiltrated with leucocytes, and this is especially noticed around the hiatus muscularis through which the vessels enter. The mucous membrane is thickened, engorged, and infiltrated with polynuclear leucocytes, and here and there erosion or ulceration is present. If the process goes no further, healing occurs after a time, and this is often associated with *fibrosis*, which may show itself (*a*) as a more or less generalized sclerosis of the whole appendix (Plate VII., Figs. 1 and 2), which may remain stiff and hard, and is perhaps twisted on itself (Fig. 497); or (*b*) as a stricture of the tube (Fig. 496), which leads to retention of a mucous or muco-purulent effusion (hydrops or empyema of the appendix); sometimes a fæcal concretion forms distal to the stricture, and in all cases there is a greater tendency to recurrence, which is often of a severer type than the original attack; or (*c*) obliteration of the appendix may occur from the union across its lumen of granulating surfaces. This usually commences at the tip and works up towards the gut, but

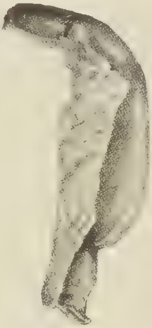


FIG. 496.—APPENDIX WITH STRICTURE AT PROXIMAL END.

The patient was a boy, aged seven years, who had had several attacks of pain in the abdomen, with high temperature lasting a few hours, sickness, and tenderness in the right iliac fossa, evidently due to retention of secretion.

is not completed until the patient has suffered from many attacks. (*d*) Occasionally small *diverticula* or pouches form as the result of a hernial protrusion of the mucous membrane through some gap in the muscular wall—*e.g.*, the hiatus muscularis. They are usually not larger than a hemp-seed, but are of importance, since the thin walls would readily give way as the result of any intra-appendicular tension from effusion, and thereby a perforative peritonitis might be lighted up.

When *ulceration* occurs, the loss of substance of the mucous membrane may be slight or extensive; it may be a simple erosion associated with a mild catarrhal attack, or a deeper loss of substance due to the presence and impaction of a fæcal concretion; or it may result from a specific infection, as from typhoid fever or tuberculous disease. The appendix is then likely to be more seriously invaded with micro-organisms, and *suppuration* of many types may ensue. It may contain muco-pus in its lumen, and this may increase to the point of determining rupture of the appendix within a few hours, or the whole wall of the tube may be yellow with a diffuse purulent infiltration. The ulceration may gradually spread through the walls and lay open the peritoneal cavity, giving rise to a local or diffuse suppurative peritonitis.

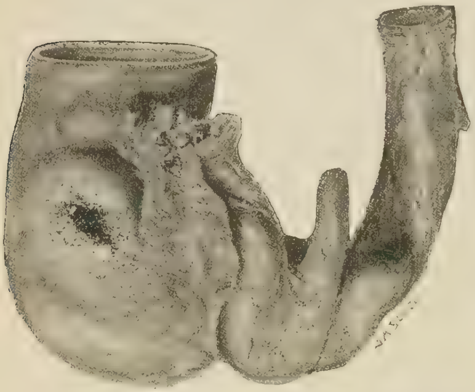


FIG. 497.—VERMIFORM APPENDIX TIED DOWN BOTH TO CÆCUM AND ILEUM, AND DOUBLED ON ITSELF BY OLD-STANDING ADHESIONS.

The appearances in this illustration are very characteristic of what is frequently seen; but the case from which it was taken was a very unusual one. It occurred in a baby of seven days, who was operated on for acute obstruction due to the adhesions, which were old-standing, and evidently ante-natal. The child died, and the cæcum was subsequently removed.

Necrosis or *sloughing* of the appendix occurs in the more severe forms. It is due to an acute interstitial inflammation spreading from an impacted concretion, or from an ulcer of the mucosa; or results from kinking and thrombosis of the appendicular vessels in the meso-appendix. The whole appendix may slough, or merely a portion (Plate VII., Figs. 3 and 4), and then usually the tip or the part immediately opposite the distal end of the meso-appendix. The necrotic tissue is soft and easily torn, of a blackish, brown, or green colour, and usually extremely offensive. It may be associated with a *perforation*, through which the concretion may escape (Fig. 498). In all these cases a grave peritoneal infection follows.

(2) **Changes in the Cæcum** often accompany appendicitis. In the *catarrhal* variety a generalized typhlo-colitis is often present, and perhaps it would be more correct to speak of appendicitis as a complication of that condition. It is in these cases where the cæcum and colon are inflamed and tender, as well as the appendix, that most careful discrimination is needed in order to prevent needless operation which will not improve the patient's condition. In *suppurative* appendicitis the cæcum is generally inflamed and infiltrated, but rather from the peritoneal aspect than from within; operative treatment will in these cases be quickly followed by resolution. Rarely does the inflammation become so severe as to lead to suppuration or necrosis of the wall of the cæcum; should this occur, it usually involves the origin of the appendix, and may be followed by a fæcal fistula.

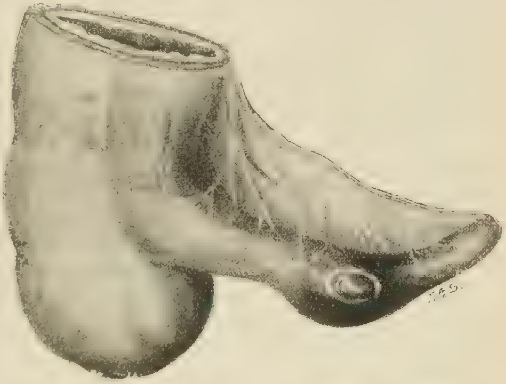


FIG. 498.—PERFORATION OF THE APPENDIX FROM AN IMPACTED CONCRETION, CAUSING AN ACUTE ABSCESS (SEMI-DIAGRAMMATIC).

(3) The **Peritoneal Phenomena** associated with appendicitis are of the utmost importance.

In the milder cases the peritonitis is protective in type. The serous coat of the appendix becomes inflamed, sheds its endothelium, and becomes roughened by a deposit of lymph, and this results either in a thickening of the wall, or in a formation of *adhesions* which tie down the appendix in various directions and positions. Most commonly it is simply fixed to the cæcum along part of its length, but sometimes it is firmly united to it for its whole extent. Adhesions may pass between the appendix and the omentum, the mesentery, or ovary, etc.; in fact, the appendix may be united to almost any of the viscera, and may thereby hamper their action or give rise to some form of acute obstruction. It may also contract adhesions to the fasciæ—*e.g.*, over the psoas sheath or iliac vessels, and various symptoms may be caused thereby.

In the graver cases an infective peritonitis occurs, and, according to the virulence of the organisms, the defensive powers of the patient, and the character of the infection, the process may be localized or not. A *localized intraperitoneal abscess* is by no means uncommon; its extension is limited by the formation of adhesions between the omentum, the parietes, and neighbouring coils of intestine.

Its exact anatomical relations depend on the original situation of the appendix (see Plate VIII.). Frequently it is located below and behind the cæcum; sometimes it burrows down into the pelvis; in other cases it passes inwards amongst the intestines; it may track up towards the liver either on the inner or outer side of the ascending colon. The abscess may burst externally, and its approach to the surface will be heralded by brawny swelling, redness, and œdema; the most frequent sites for external pointing are the outer part of the iliac fossa and the lumbar region (Petit's triangle). It may burst into any of the viscera, and then most commonly into the cæcum or bladder. Finally, it may break through the peritoneal adhesions, and involve the general serous cavity, causing acute diffuse peritonitis; in other cases a serous effusion into the peritoneal cavity is found, resulting from the irritation of the abscess, and disappearing when it is opened. The pus contained in the abscess is usually of a stinking character, and in cases of sloughing of the appendix the fœtor may be intense; but it must be remembered that the amount of smell is no gauge of the virulence of the process. Sometimes the débris of a broken-down concretion can be recognised in the pus, and sometimes a portion of the appendix as a slough. Gas is also present in some cases, having escaped from the bowel, or been generated by the activity of gas-producing organisms. It is not always possible to distinguish the appendix in these abscesses, even when it has not sloughed off; it may be firmly adherent to the cæcum, and unrecognisable to the examining finger.

In the worst cases, associated with perforation or necrosis of the appendix, a *spreading septic peritonitis* is frequently observed, with but little tendency to limitation; an abundant sero-purulent effusion occurs, due largely to the presence of streptococci, and later to invasion by the *B. coli*. The line of diffusion is governed by the anatomical relations of the appendix; most commonly the effusion involves the pelvis, and after filling Douglas's pouch, spreads up on the left side to the inner aspect of the sigmoid meso-colon. If the appendix is situated above the brim of the pelvis, the effusion will extend to the right kidney pouch, and a subphrenic abscess be thereby determined. If it spreads beyond these limits, the whole peritoneal cavity will be affected, and operative treatment is little likely to be successful. The effusion in the first place is serous, but soon becomes turbid, and finally fibrino-purulent or frankly purulent. Experience proves that as long as the exudate is serous or merely sero-purulent, operative treatment holds out good prospects of recovery. In later stages the intestine becomes matted together by lymph, and paralyzed, and a cure is almost hopeless.

(4) **Extra-peritoneal suppuration** occasionally follows, and is then usually due to extension backwards through adhesions formed between the appendix and the peritoneum on the posterior wall of the abdomen or pelvis, thereby leading to infection of the retroperitoneal connective tissue. The pus may collect in the iliac fossa and point anteriorly; or may track downwards into the pelvis and

PLATE VIII.

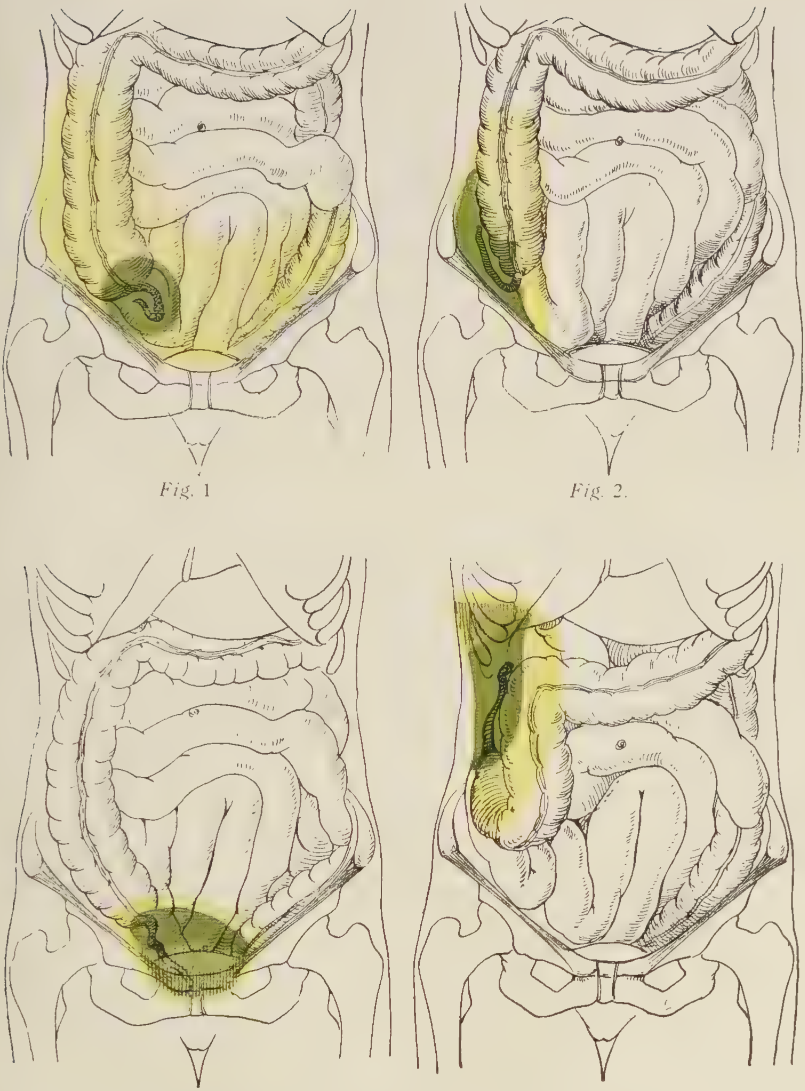


Fig. 1 *Fig.* 2.

Fig. 3. *Fig.* 4.

Diagrammatic representation of the distribution of the effusion in acute Appendicitis according to the position of the Appendix *(after Quervain).*

Fig. 1.—Appendix in right iliac fossa ; abscess localized in fossa, but diffuse effusion spreads widely up along the colon down to the pelvis, across the middle line to the left side.

Fig. 2.—Appendix to outer side of cæcum ; abscess localized.

Fig. 3.—Appendix in pelvis (pelvic appendicitis).

Fig. 4.—Appendix reaching up towards the liver with cæcum twisted ; abscess subhepatic and mainly localized to the right loin.

Yellow—serous or sero-purulent effusion. Green—pus

[*To face page 1046.*

open into the rectum; or may travel along the psoas tendon and open into the thigh; or burrow upwards into the loin, forming a perinephritic collection, or a retroperitoneal subphrenic abscess, and then may extend even into the thorax.

(5) Various **complications** may be associated with any of these different types of appendicitis. (*a*) The veins in the meso-appendix may become thrombosed and infected with pyogenic organisms; detachment of emboli may lead to the occurrence of *pylephlebitis* and pyæmia. (*b*) *Thrombosis* of the femoral veins may develop; if on the right side, it is probably due to implication of the right iliac vein in the inflammatory process; but if it happens, as is much more common, on the left side, it must be due to general toxic causes; or, if it occurs after operation, to spreading thrombosis from vessels divided in the anterior abdominal wall (p. 343). (*c*) Chronic or subacute ovaritis often accompanies appendicitis in women; it is probably due to the position of the appendix which hangs over into the pelvis. (*d*) Various renal complications may supervene, usually from pressure of the inflammatory mass on the renal vein, or on the ureter as it crosses the pelvis brim, resulting either in hæmaturia or in renal colic. (*e*) Inflammation of an appendix located in a hernial sac is referred to hereafter (p. 1087). (*f*) Lastly, intestinal obstruction may be induced by the acute inflammatory attack leading to paralysis of the intestinal wall, or it may develop subsequently as a result of kinking or strangulation by bands or adhesions.

Clinical History.—(i.) The mild variety of the disease, known as a simple **catarrhal appendicitis,** to which is added merely a localized plastic peritonitis, usually commences somewhat suddenly, the patient being seized with pain, which is at first referred to the umbilicus or to any part of the abdomen, but at the end of twenty-four to forty-eight hours localizes itself in the right iliac fossa. It is often of a sharp, cutting character, but varies much in intensity and duration. Fever is usually present, and the attack may start with a rigor. The patient may complain of nausea and vomiting, but the latter symptom does not last long. Constipation results from the intestinal paralysis due to the inflammatory lesion, but in children it is sometimes replaced by diarrhœa, and that even blood-stained, so that a diagnosis may need to be made from typhoid fever.

On examination the abdominal wall is found to be more rigid than usual; the right leg is often drawn up to relax the muscles, and in bad cases all abdominal respiratory movements are abolished. Even in mild cases the muscles over the right iliac fossa are held tense and rigid so as to guard the underlying structures. Definite tenderness is noted on pressure, and the patient will often, but by no means constantly, refer it to a spot about 1½ inches from the anterior superior iliac spine along a line drawn to the umbilicus (McBurney's spot; Fig. 480, A). In many cases, when the appendix is directed backwards, there is marked tenderness in the lumbar region; but if it points downwards into the pelvis, the pain and tenderness may not be evident except on rectal or vaginal examination, which should never be neglected. A definite swelling may sometimes be detected by palpation, usually above the outer half of Poupart's ligament, but varying in its position with the site of the appendix; it may be dull on percussion, but is frequently tympanitic, since it consists of coils of intestine and omentum matted together around the appendix. The absence of a definite lump is due to the non-development of protective adhesions, and hence is noted in the worst cases of perforative appendicitis; or it may be caused by the inflamed mass lying deep in the abdomen, and being covered over by distended and uninflamed intestine.

This simple form of the disease usually lasts three or four days, and then, if properly treated, resolves satisfactorily without abscess formation. It is exceedingly common, and the prognosis is, on the whole, favourable. Tofft, of Copenhagen, found adhesions in the neighbourhood of the appendix in 35 per cent. of all bodies subjected to post-mortem examination.

(ii.) The more serious variety, commonly resulting **in a localized abscess,** may commence in a similar way, but with more acute symptoms. There may be an initial rigor, and the temperature soon runs up, even to 104° F. Some general abdominal tenderness and distension follow; constipation is often absolute, and fæcal vomiting may occur, although diarrhœa is not unknown, especially in children. The muscles on the right side of the abdominal wall are held tense and rigid, and a well-marked fulness can sometimes be detected in the iliac fossa. In other cases a distinct swelling can be seen as well as felt, and is not necessarily limited to the right fossa, but may be found in the middle line of the abdomen or elsewhere. Under a careful régime this may disappear, and the symptoms gradually abate in their severity, the temperature and the pulse falling concurrently; but it is very common for suppuration to ensue, and this is indicated by the temperature persisting at its original high level, or by the pulse-rate increasing in rapidity, whilst the temperature falls. Fluctuation is rarely to be detected in the early stages, and, indeed, it is bad practice to wait for it before interfering, since there is a considerable probability that the tension within the abscess may be sufficient to break down the wall of newly-formed and not too strong adhesions, and the general peritoneal cavity may be thus infected. The abscess develops at first round the appendix, and is, of course, primarily intraperitoneal. Occasionally it bursts into the bowel, and thereby relief is gained without the assistance of surgery; some authorities, indeed, maintain that this occurs in every case of the more severe type which resolves. In other instances it may point externally, either through the anterior abdominal wall, which becomes congested and œdematous as the pus approaches the surface, or through the loin. Not unfrequently it tracks up along the inner or outer side of the ascending colon, and then may get into relation with the under surface of the liver. In other patients, and especially when the tip of the appendix lies over the brim of the pelvis, the pus travels downwards and forms a collection in front of the rectum; the surgeon must never omit a rectal examination in appendicitis, where the temperature is of such a nature as to suggest the existence of an abscess, and yet no evidence of one can be found. Should it burst into the peritoneal cavity, all the phenomena of acute perforative peritonitis with grave toxæmia supervene, probably indicated by severe pain, sudden fall of temperature, rapid collapse, and failure of the circulation, leading rapidly to a fatal issue, preceded by increasing abdominal distension.

In not a few cases the patient's general symptoms improve after the first outbreak; the temperature may become normal, the pain decrease, and the vomiting cease. It is often difficult to be certain whether this improvement is merely temporary, or is the commencement of a true convalescence. Under the former circumstances—*i.e.*, if it is merely an *interval of quiescence*—careful examination will probably reveal some disturbing factor; either the abdominal distension persists, or perhaps hiccough is present, or well-marked tenderness continues, perhaps only to be detected *per rectum*, or the pulse-rate may remain unduly high. After a few days the temperature begins to rise once more, the focal symptoms become more urgent, and a localized abscess forms.

It is often by no means a simple matter to make certain that pus is present; but considerable assistance can be derived from a blood count, which is advisably made each day that the uncertainty persists. Readers are referred back to p. 62 for a full consideration of *leucocytosis ;* it will suffice here to state that a leucocyte count under 20,000 is merely indicative of an inflammatory attack well resisted; if suppuration is present, the leucocytes are usually over 20,000. In the early stages, however, a high leucocyte count means comparatively little; but a maintained leucocytosis is a valuable sign of suppuration.

A complication likely to occur in the more severe types of the disease is *pylephlebitis*, or infective thrombosis of the branches of the portal vein in the liver. This would be indicated by recurrent rigors, and possibly by pain and tenderness in the hepatic area. Necessarily it is almost invariably fatal.

(iii.) In the graver forms of **diffuse or generalized peritonitis,** the onset is usually sudden, the patient becoming collapsed with the severity of the pain; vomiting often accompanies the outbreak and occasionally a rigor. These symptoms sometimes pass over directly into those of generalized peritonitis, as described on p. 975, death ensuing in two or three days; the temperature in such cases may be low, and the absence of reactive phenomena is indicated by a leucopenia. More frequently the course is not quite so acute; the pain which at first is referred to the umbilicus becomes localized to the right iliac fossa; the abdominal wall on that side is held rigid, and the rigidity gradually spreads across the abdomen to the left iliac region and upwards towards the liver; vomiting and absolute constipation are present, and the temperature is usually raised three or four degrees; the pulse varies from 100 to 120, and the amount of urine passed is diminished in quantity. If surgical treatment is not undertaken early, the typical phenomena of acute diffuse peritonitis are soon developed.

(iv.) **Relapsing Appendicitis** is the term applied to a condition when an attack passes off, but not quite satisfactorily. There may be a slight persistent rise of temperature at night; or the appendix remains palpable and tender; or some amount of appendicular pain often of a colicky character may be noted. In many of these cases the symptoms are due to unhealed ulceration of the mucous lining or to stenosis of the tube. If left alone, a more acute outbreak may supervene, or bacterial invasion of the vessels in the meso-appendix may follow, and serious consequences develop. If an attack of appendicitis has not cleared up completely at the end of a week or ten days, an operation is always advisable for the removal of the organ.

(v.) **Recurrent Appendicitis** is characterized by repeated attacks of varying gravity in an individual who has been once the subject of the disease. They may occur only at prolonged intervals, or be so frequent as entirely to incapacitate the patient, and are usually associated with the presence of some abnormal adhesion or constriction of the appendix. It is not uncommon for the appendix to become fixed to the sheath of the psoas muscle, and then any excessive movements of the limb may light up an attack. Where stenosis exists, secretions containing bacteria may be pent up behind the constriction, and from time to time the patient suffers from severe pain of a colicky nature with or without fever, supposed to be due to an attempt to get rid of the excess of mucus. Such attacks have been named **appendicular colic.** In a few cases the appendix becomes totally obliterated after a time and incorporated in a mass of adhesions, a natural cure being thus established, but more frequently, if these occurrences are allowed to continue, the patient finally develops an abscess, possibly from the infection of some unobliterated portion of the tube, or succumbs to diffuse peritonitis.

Recurrences are more common after the simpler forms of the disease, and it has been calculated that over 30 per cent. of the subjects of a mild catarrhal attack suffer in this way. In the more acute forms recurrence is less common, and it is unusual for a case to recur when suppuration has existed; we have, however, seen cases where an abscess has developed two and even three times in connection with attacks which were separated by intervals of complete disappearance of symptoms.

(vi.) **Appendicular Gastralgia** is the name applied to cases in which all the signs and symptoms of the disease are referred to the epigastrium, and closely mimic those of a gastric or duodenal ulcer. The patients are usually women, and a test-meal examination reveals a hypersecretion of gastric juice, in which the hydrochloric acid may be increased or diminished. Laparotomy shows no lesion in the stomach or duodenum, but chronic appendicitis is usually present.

That the previous symptoms were due to the condition of the appendix is proved by the relief to the symptoms and the changes in the gastric secretion after appendicectomy. The probable explanation is that the condition of the appendix causes intestinal stasis, and this in turn sets up a toxæmia which reacts on the gastric mucous membrane. The condition is important clinically, as it emphasizes the importance of finding definite evidence of a lesion in the stomach or duodenum before performing gastro-enterostomy for supposed gastric or duodenal ulcer. Not unfrequently these patients are also the owners of a moveable and tender right kidney.

Diagnosis.—In a well-marked case the symptoms of appendicitis are so typical that the diagnosis can never be in doubt. The pain, tenderness, fever, vomiting, constipation, abdominal rigidity, and perhaps tumour, constitute a picture that is quite characteristic. The disease, however, often presents symptoms so varied, and manifestations so protean, that one is never surprised to meet with it in all sorts of diverse settings, and many mistakes of diagnosis are made, even by the most skilled clinicians.

The early stage of *pneumonia* is sometimes associated with severe pain and tenderness in the iliac fossa, especially in children, and the resemblance to appendicitis is the more marked when the onset is sudden, and abdominal rigidity and vomiting are present. A careful examination of the lungs should never be omitted in the case of children with suspected appendicitis. Cases which commence with diarrhœa may be mistaken for *enteric fever*, but the absence of the rash and a negative Widal's reaction should guard the practitioner from error. Recurrent appendicular pain may be mistaken for that of *renal colic* or for the painful attacks associated with displacement of a floating kidney (*Dietl's crises*), or *vice versa* ; and the difficulty is increased if hæmaturia or irritation of the bladder are caused by an appendicitic effusion or abscess. *Biliary colic* may be simulated, whilst a *distended and inflamed gall-bladder* may closely resemble an appendix abscess which has travelled upwards.

Perforation of the duodenum, or even of the *stomach*, may lead to symptoms very similar to those of appendicitis, due to the inflammatory mischief tracking downwards. The initial pain will usually be referred to the upper part of the abdomen, and there may be evidence of free gas in the peritoneal cavity. If gas escapes from the abdomen on operation, and is free from odour, the probability is that the lesion is gastric or duodenal. *Mucous colitis* simulates chronic appendicitis, and the appendix is indeed often involved in the mischief. The distinction is made by the tenderness being located over the whole course of the colon, and by the passage of mucus in the stools. *Tubal* and *ovarian* diseases are recognised on pelvic examination; but the fact must not be overlooked that chronic appendicitis is often associated with inflammation of the right ovary, and then attacks of pain may occur at each menstrual period A small ovarian dermoid with a twisted pedicle may resemble appendicitis very closely in the absence of a vaginal or rectal examination.

A considerable swelling in the right iliac fossa may result from repeated attacks due to a matting of the parts together, and a diagnosis from tuberculous or malignant disease is sometimes difficult apart from operation. The history may be spread over a longer time, however, in appendicitis.

In abdominal abscesses the possibility of an appendicular origin must always be kept in mind, as they may occur in any part of the abdomen; and it is often only by a careful exploration of the cavity that we can trace the cause to the appendix.

The diagnosis from acute obstruction is noted hereafter (p. 1131).

The **Prognosis** is never absolutely certain, for, as has been well pointed out by many acute observers, the initial symptoms are frequently alike in all the varieties, and hence one can never know what course the case is going to take; as R. Morris, of New York, says, 'The infected appendix is a cap which sometimes snaps, sometimes flashes, and sometimes causes an explosion, and none of us can tell in advance just what is going to happen.' As particularly bad signs may be mentioned a continued high temperature, in spite of rest and careful dietetic measures, or a fall of temperature with increased rate of the pulse. Persistent hiccough is also a bad sign. The existence of a swelling in the iliac fossa is not a bad sign, but rather the reverse. Absence of a localized swelling is due either to a defective formation of protective adhesions, and hence is likely to be noted in the most acute cases, or to the appendix being placed behind the cæcum in a position less favourable to operative measures.

Treatment.—So much has been written on this subject during the last twenty years, that it is extremely difficult to compress even a brief summary of the many facts observed into a necessarily limited space. Formerly perityphlitis was the exclusive property of the physician; but a great change has occurred, and many authorities consider that appendicitis is more justly within the realm of the surgeon, or, at any rate, that a surgeon should always share the responsibility of treatment with the physician. At any moment complications may develop even in cases which appear to be simple, when immediate surgical assistance will alone hold out any hopes of saving the patient. In America surgery is the recognised treatment for almost every case of the disease, as soon as it is diagnosed; in this country conservative ideas still persist, but a more healthy opinion is gaining ground, and surgical interference is becoming recognised as the most appropriate means of treatment in most instances.

1. In the mild catarrhal type of appendicitis, where the temperature does not run above 101° F. and the symptoms are not severe, all that is required in the majority of cases is to put the patient to bed, and apply fomentations locally; the lower bowel should be emptied by an enema after a rectal examination has determined that no abscess or serious pelvic complication is present; if it seems likely that there is an accumulation of irritating fæces within the intestine, *one* dose of castor oil or of calomel *may* be administered, but not

without due consideration. A fluid, unstimulating diet is all that is permitted, and should there be much vomiting, rectal alimentation may be resorted to. Possibly morphia may be given with advantage to quiet the patient and check peristalsis, thereby facilitating the formation of protective adhesions; but the less the better, since it tends to mask symptoms.

The question of operation for this mild type of disease can be readily compressed into the three following propositions:

(*a*) If the condition is not showing signs of improvement at the end of forty-eight hours—*i.e.*, on the third day—in spite of appropriate treatment, the case should be looked on with suspicion as probably one in which suppuration is occurring, and operation is desirable.

(*b*) If the appendix remains tender and palpable after an attack, and especially if the temperature rises slightly at night, the organ should be removed without delay.

(*c*) As soon as the attack is really quiescent—*i.e.*, generally in nine to ten days—the appendix should be removed. This proposition may not be generally accepted; but it is absolutely logical, and daily experience is emphasizing the conviction as to its accuracy. In the first place, recurrence is common, and the figures given above (viz., 30 per cent.) probably underestimate its frequency. Then, too, it is impossible to tell which cases will recur and which escape, whilst the recurrent attack is frequently more severe than the first, and often accompanied by suppuration. Moreover, each recurrent attack is likely to add to the adhesions present, so that whilst removal after a first attack is an easy proceeding, removal after many recurrences may necessitate a long incision and a troublesome or dangerous dissection, complicated, perhaps, by unintentional perforation of the bowel, or even enterectomy. Finally, it may be necessary to keep the patient very quiet and to limit his diet and his activities considerably if recurrence is to be avoided; and such practice in a breadwinner may be a serious matter. By removing the appendix, either during or immediately after the attack, this period of disability will probably be reduced to a minimum.

Operation in the Quiescent Period.—The muscle-splitting plan suggested by McBurney may well be adopted when it is probable that but few adhesions are present. The incision is an oblique one, about 2 to 3 inches long, crossing McBurney's spot or a little below it, and parallel to the outer end of Poupart's ligament, somewhat similar to that for ligaturing the external iliac artery (Fig. 473, C). The external oblique is exposed, and incised in the course of its fibres; the divided segments are held well aside by retractors, so that about 2 inches of the internal oblique muscle come into view. The exposed fibres of this muscle run nearly in the same direction as those of the transversalis muscle, and the two can be split together by a transverse incision. The introduction of large deep retractors will expose a square or diamond-shaped area of subperitoneal fat or peritoneum about 1½ to 2 inches in diameter. The peritoneum is divided transversely, and the margins grasped for identification purposes by Spencer Wells forceps. The cæcum probably presents, and is gently withdrawn. The anterior longitudinal muscular band conducts to the appendix, which is freed from adhesions and removed. The meso-appendix is first divided after securing the vessels in it by a ligature. The serous and muscular coats are then divided by a circular incision and peeled back like a cuff, leaving the mucous membrane as a narrow tube. The retraction is carried back so as to enable a ligature to be placed around the tube of mucous membrane flush with the cæcum (Fig. 499). The distal end is grasped with Spencer Wells forceps, and cut away after protecting the parts below with a strip of sterilized gauze. The protruding portion of mucous membrane is carefully curetted, and the sero-muscular cuff replaced over it. A purse-string suture is then introduced through the serous and muscular coats all round it; the appendix stump is gently invaginated into the cæcum by a pair of forceps, and the suture tied; by this means the stump of the appendix is buried and covered over completely with peritoneum (Fig. 500). The site of detachment of the meso-appendix, or of the position from which the appendix itself has been detached, may require a few sutures in order to ensure a complete peritoneal coating, and thus minimize the risk of subsequent adhesions.

All bleeding-points having been secured, the cæcum, which has been protected during the operation by a warm wet sterilized cloth, is returned into the abdomen, and finally in the female the right ovary and tube are carefully examined. The abdominal wound is then closed, layer by layer, without drainage.

If, however, it seems probable that many adhesions are present, the muscle-splitting operation should be avoided, and the abdominal parietes divided in the line of the cutaneous incision, so as to allow the wound to be enlarged up or down as may be desired. The severance of these adhesions may be a most tedious and troublesome procedure, but when once it is effected the appendix is amputated as described above. In some of these more serious and prolonged operations it may be desirable to drain the iliac fossa by a tube or gauze wick for a short time.

In the more serious cases the patient should remain in bed for three weeks, to allow the bond of union to become firm, and avoid all needless strain for some months, but in the simpler cases may be allowed up in a fortnight.

2. In the gravest variety of *fulminating appendicitis*, associated with diffuse septic peritonitis, there can be no question that the only hope of recovery lies in immediate operation. When the peritonitis is extensive and the exudate purulent, this hope is but slender in the extreme; if, however, the effusion is mainly pelvic, and still of a sero-purulent type, it is possible that a considerable percentage of the cases may be saved. Hence, whenever the attack starts with severe pain, frequent vomiting, and early collapse, whilst the abdomen shows marked signs of rigidity but may not be distended, no time

should be lost in operating. In such cases the appendix is either perforated, and then every hour adds to the mischief; or it is acutely distended with muco-pus, and may perforate at any moment, giving rise to a general infection. No possible good can be derived by delaying operation in these severe cases. The abdomen is opened, either through the middle line or in the right iliac fossa; the appendix is looked for and removed, and effusion, if present, is swabbed or washed away with sterilized salt solution at 108° F. Drainage may be omitted in some of the early operations, even if effusion has been present; but in most instances it is necessary, and may then be provided by tubes or gauze wicks.

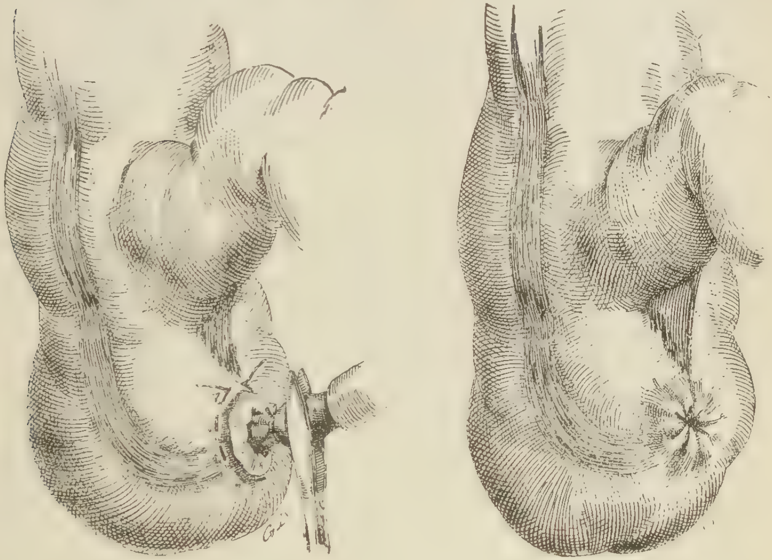


FIG. 499. FIG. 500.

AMPUTATION OF THE APPENDIX.

In Fig. 499 the cuff of sero-muscular tissue has been dissected up, exposing the tube of mucous membrane, to which a pair of Spencer Wells forceps is applied distally, whilst a ligature is placed on its proximal end. The purse-string suture has been introduced around its base.

In Fig. 500 the purse-string suture has been tied after tucking in the sero-muscular cuff, thereby burying the stump of the appendix.

3. When an abscess is evidently present, being indicated either by fluctuation or by a commencing œdema of the abdominal wall, there should be no hesitation in cutting down. An incision is made over the œdematous spot, and deepened carefully, since the tissues are probably matted together, and cut like bacon or brawn. The knife or index-finger may suddenly sink into the abscess cavity, and a gush of fœtid pus follows. The cavity is gently explored, so as

to ascertain whether or not the appendix can be felt; no undue force should be used, for fear of breaking down adhesions and thus opening the general peritoneal sac. If the appendix cannot be readily found, it is best left alone; the abscess may be gently irrigated, drainage is provided for, and the incision partly closed. Probably the case will go on well, the discharge losing its smell about the third day, and the remaining sinus will gradually heal by granulation. Should the appendix, however, present itself, it should be removed.

4. There is still, however, a large group of cases in which none of the above conditions is manifest, and yet the symptoms, both local and general, indicate that a lesion of considerable gravity is present. The attack may have commenced more or less acutely, but has progressed steadily. Much difference of opinion has existed as to the desirability of operation in these cases, and especially as to the most favourable time for such a procedure. It must be admitted that in many instances conservative or medical treatment will suffice to bring about a satisfactory result, but this can never be depended on, and, unfortunately, the experience of all surgeons is that only too frequently have they been called in to operate on patients who have been brought into the gravest jeopardy of their lives through undue delay. Either they are suffering from generalized peritonitis, or are profoundly toxæmic by absorption from a large abscess, or exhausted by previous suffering; possibly other complications have arisen due to extension of thrombosis or dissemination of emboli. Operation under such circumstances is always risky, and even if the local conditions are effectively dealt with, the patient may subsequently succumb to toxæmia, septicæmia, pulmonary embolus, or other manifestations of blood-poisoning, perhaps aggravated by the operation.

The objections usually raised to early operation are that it involves the removal of the appendix from a certain number of people who might get well without operation, and that it is not the best time to operate when inflammatory phenomena are present. The answer to these objections is quite obvious, viz., that the prognosis in any case is so hopelessly uncertain that the risks involved in waiting for a quiescent interval on the one hand, or for the development of undoubted indications of the presence of pus on the other, are much greater than those of an operation undertaken at an early date by a skilful surgeon. Moreover, an appendix that has once been inflamed is of no service, and may be a source of grave danger to its possessor, and the sooner he is rid of it the better. Extensive experience of the early operation proves that pus is frequently present at quite an early stage of the affection—*i.e.*, within twenty-four hours or less—and one rarely operates on any case where the symptoms are at all severe without finding cause for gratification that delay had not been counselled. Moreover, statistics prove that the mortality associated with operation during the inflammatory attack is much less when it is undertaken on the first day (1·2 per cent.) than on any of the successive days up to the sixth or seventh.* The chief advantages of an early operation may be indicated as follows: (*a*) That the patient is not in a state of collapse from toxæmia, and hence can easily stand the shock of an intraperitoneal exploration; (*b*) that the amount of effusion likely to be present is small, and hence can be easily dealt with and safely removed with but little risk of infecting the general peritoneal cavity or the abdominal wall; (*c*) that the appendix can usually be found, isolated, and removed without much difficulty; in the later stages where a large abscess exists this may be impracticable, and a second operation for its removal may be required later on, and then the appendix may have to be 'dug out' of a mass of adhesions, and serious risks taken; and (*d*) that a smaller incision will be required, and hence there will be less likelihood of the subsequent development of a hernia. One would therefore claim that the following rule is both reasonable and justifiable, and that its observance will be beneficial, viz., that in cases of moderate severity *if in spite of suitable rest and medical treatment the symptoms, both general and local, are not commencing to abate at the end of forty-eight hours, operation should be undertaken,* and still more so if any of the following conditions, indicative of the formation of an intraperitoneal abscess are existent, viz., a steady rise in the leucocyte count, or one above 20,000, especially if maintained for twenty-four hours; persistent distension of the abdomen, a maintained high temperature, hiccough, or a continued high pulse rate, in spite of a falling temperature. Of course, a localized swelling which persists or increases in size and becomes more tender, will also indicate operation.

5. Not a few cases will be observed in which the initial symptoms quiet down at the end of twenty-four or forty-eight hours, but after an interval of quiescence of varying length the phenomena suggestive of suppuration show themselves. In such patients operation should be advised immediately, as an abscess is obviously developing.

Operation for Suppurative Appendicitis.—Ether should always be the anæsthetic, if possible; the mortality after operation when chloroform is employed is decidedly higher. The incision will vary with the physical signs and the site of maximum tenderness. The whole thickness of the abdominal wall is divided, and it is well to make a sufficiently large opening; an extra inch of incision may make all the difference between blindly groping in the dark and seeing clearly what one is doing. The general arrangement of the parts is noted, and the peritoneal cavity protected from purulent infection by packing in sterilized gauze; one strip is usually passed upwards along the ascending colon, one downwards into the pelvis, and one internally to protect the small intestines and general serous cavity. The cæcum is then gently lifted from its bed, and the abscess will usually be found behind it. Every effort must, of course, be made to prevent soiling of the unaffected peritoneum. Whenever possible, the appendix should be removed, but not unfrequently a formal amputation is impracticable. A ligature, and preferably of catgut, which can be absorbed, is then tied around the base about ½ inch from the cæcum, and the appendix cut away; the stump is guarded by a gauze strip passed down to it from the wound and used for drainage. Not unfrequently, however, the appendix does not appear, and then it may be better to leave it alone; in many cases, however, an experienced surgeon will be able to detach and remove it. The cavity is emptied of pus by swabbing it out, and a careful but thorough exploration of the pelvis and right kidney pouch made to ensure that pus is not shut up in these regions. Finally, the cavity is packed in such a way as to drain it thoroughly, and yet to protect the surrounding parts. The abdominal incision is partially closed.

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* See Hugh Lett, 'The Present Position of Acute Appendicitis,' *Lancet*, January 31, 1914.

The packing is gradually removed in the next two or three days, and after the general cavity has been shut off by the development of adhesions, irrigation with salt solution or peroxide of hydrogen is permissible. The wound heals by granulation, and when nearly flush with the surface may be drawn together by strapping, so as to limit the chances of development of a ventral hernia.

Sequelæ.—A *Fæcal Fistula* may result from a perforative appendicitis when the abscess has been merely opened, and no radical treatment undertaken at the same time, or it may follow an amputation of the appendix from sloughing or yielding of the stump. It is usually small in size, and sinuous in its course, and in the majority of cases closes of itself. Occasionally it is necessary to deal with it by laying bare the cæcum in the iliac fossa, and removing the appendix or suturing the opening. Failing that, it may be necessary to short-circuit the cæcum.

A *Ventral Hernia* sometimes follows from the yielding of the cicatrix in the abdominal wall after an abscess has been opened and drained. Both omentum and bowel, perhaps matted together and adherent to the cicatrix, are found in the protrusion. In some cases it may suffice to protect and restrain it with a truss, but in others operation is required; adhesions must be divided or broken down, and often the opportunity can be taken for removing the appendix, if this has not already been accomplished. The margins of the divided muscles are then sought for, and united by a row of buried sutures in the ordinary way, or overlapped as described in discussing the subject of ventral hernia (p. 1109).

Tuberculosis of the Appendix is found not uncommonly in patients who have died of other manifestations of the disease, especially phthisis (30 per cent., Keen); it is not often seen as an independent condition, but most frequently comes under observation in men between the ages of twenty and forty, who are the subject of urinogenital tuberculous disease. The affection may develop as an ulceration of the mucous membrane, which slowly spreads from the tip and destroys the walls of the organ, giving rise finally to a large pericæcal abscess, which opens into the bowel or discharges externally. In other cases the condition is merely an element in the evolution of the hyperplastic tuberculous growth of the cæcum described elsewhere (p. 1022). Occasionally the appendix is involved in a tuberculous peritonitis, and then the trouble may either have started in the appendix, or have reached it secondarily from the serous coat. The symptoms of these conditions are in no ways peculiar, and correspond to those of a chronic appendicitis.

Actinomycosis attacks the appendix more frequently than any other abdominal organ. The disease originates usually from the ingestion of infected material, and the result is the production of a hard, slowly-enlarging mass, infiltrating the tissues in the right iliac fossa. Sooner or later the skin gives way, and then the discharge of glairy pus and of the yellow sulphur-like granules, together with the musty smell, is pathognomonic. Pyococcal infection of the sinuses is only too likely to follow, sometimes originating from within the bowel, and the case then becomes complicated by a suppurating element which has an important bearing on the result. Secondary foci are common, especially in the liver (p. 1067). **Treatment** consists in the excision of the appendix and even of the cæcum, if such be practicable, or in the exhibition of large doses of iodide of potassium with curettage and drainage; but even when the organisms have been destroyed by the drug, the discharge of pus may continue, and the affection may prove fatal.

Primary Carcinoma of the appendix is noteworthy on account of its slight malignancy. The case presents the history of a chronic appendicitis, in no ways peculiar, and on operation the growth is discovered. Removal is usually followed by freedom from recurrence. The condition is, however, very uncommon. **Sarcoma** has also been known to occur in connection with the appendix, but the prognosis is less favourable.

Affections of the Liver.

Displacements of the Liver are obviously not likely to be common, since the organ is well supported, both by ligaments and attachments to deep structures, and by the intra-abdominal pressure. Should, however, the abdominal parietes be relaxed and the intra-abdominal pressure lessened, it is possible for the liver to sink, and thus *hepatoptosis* becomes an element in the syndrome known as Glenard's disease (p. 1028). The displaced liver is rotated forwards so that its upper wall presents anteriorly, with obvious resulting physical signs. An enlarged liver may manifest somewhat similar phenomena, but dulness is then found over the normal hepatic area; in hepatoptosis the normal site is resonant. Some amount of dragging pain and discomfort may be complained of, but this is not generally great enough to demand treatment other than the support of a belt, together with such measures as shall assist in the restoration of the abdominal wall to a state of normal tonicity. In the worst cases it is justifiable to expose the liver by an incision parallel to the costal margin, and fix it to the parietal peritoneum by sutures. The operation is conducted in the Trendelenburg position, and the patient must remain with the lower end of the bed raised for some weeks after operation.

Riedel's lobe is the name applied to a linguiform enlargement of the right lobe, which projects downwards into the loin, and is likely to be mistaken for a floating kidney. It is sometimes stated to be the result of tight lacing, but this is not invariable, and more frequently it is associated with an enlarged gall-bladder, probably containing stones, which is covered in by the projection. The lobe may have a broad base of attachment to the liver, or may be almost severed from it, and then its mobility is considerable, and may be independent of the liver. A little care in examination should enable the surgeon to differentiate between this condition and a floating kidney; if the patient be laid over on the left side, the examining hand can be insinuated between the lobe and the kidney. Treatment is not required, except, perhaps, for the condition of the gall-bladder.

Rupture of the Liver is produced by injuries to the abdominal walls, such as blows, kicks, or crushes, or it may be torn by the broken end of a rib. Penetrating injuries also occur, as from sword or dagger thrusts, and the organ may be involved in a gunshot wound. The resulting lesion varies considerably; the gland may be merely torn or contused from a non-penetrating blow, or freely incised by a sharp-cutting implement, in which case some of the larger venous trunks are likely to be divided; a bullet sometimes produces almost total disorganization. The amount of injury depends, to some extent, on the condition of the organ; if it is firm and sclerosed, it may receive little damage from a blow which would otherwise do it considerable harm, whilst if it is enlarged and fatty, it is readily torn.

The chief **Symptoms** are shock, which is often not very excessive, pain and tenderness in the right hypochondrium, and the evidences of loss of blood. The last is, perhaps, the most important, and upon its severity depends to a large extent the result. Should the capsule remain intact, there is considerable intraglandular ecchymosis and laceration, but no free blood escapes into the peritoneal cavity. Such a lesion is not unlikely to be followed by an abscess of the liver. When the capsule is torn, intraperitoneal hæmorrhage is sure to ensue; if slight, the patient, though suffering from all the phenomena characteristic of loss of blood, may recover, the blood being absorbed, and the wound in the liver cicatrizing. This process is usually attended by a certain amount of jaundice and some vomiting, whilst the urine is also tinged with bile-pigment. Well-marked pyrexia may follow the initial shock, and the abdominal wall is held rigid. In other cases, the blood collects at first in the upper part of the abdomen, but gradually extends downwards; if the bowel is uninjured, recovery may ensue, but not uncommonly there is some associated contusion of the gut wall, through which intestinal bacteria find their way, giving rise to a localized or general peritonitis. Of course, in the more severe lesions, where perhaps the left lobe is entirely torn off or a portion hopelessly contused, death from hæmorrhage is almost certain to ensue in a very short time.

The **Diagnosis** of hepatic rupture turns mainly on the history of the accident, the situation of the blow, and the resulting symptoms. Evidences of intraperitoneal bleeding, associated with pain in the right side, are extremely suggestive. It must not, however, be forgotten that the passage of a hansom cab or other vehicle over the body may give rise to much shock, and to considerable local pain and tenderness, and yet no serious mischief need have happened to the liver.

The **Treatment** in the more simple cases consists merely in careful expectancy, the surgeon holding himself in readiness to interfere should any untoward symptoms supervene. The patient is kept quietly in bed; ice may, if necessary, be applied to the side, the diet is limited to fluids, and the bowels emptied by enemata. In the more serious cases, where the diagnosis of ruptured liver is tolerably certain, an exploratory laparotomy should be undertaken, and an attempt made to deal with the wound. Possibly a median incision is as good as any, since the left half of the liver often bears the brunt of the injury. Outlying ragged portions of the gland may be totally removed, preferably by the cautery, though one usually has to depend upon plugging the wound with gauze in order to effect hæmostasis. Clean linear cuts may be sutured with silk, but there is considerable difficulty in preventing the stitches from tearing out of the friable hepatic tissue; it is wise to insert all the stitches first, taking up a wide margin of the gland substance before attempting to tie any. The wound is then carefully closed by the fingers, and the sutures slowly and gently tightened. Very shallow wounds which it is impossible to stitch or plug satisfactorily may be seared with the cautery so as to stop bleeding, and then a gauze drain is placed over them, and brought out of the external wound.

Abscess of the Liver is due to a variety of causes.

1. *Multiple Abscesses* develop in cases of pyæmia, whether the emboli are carried by the hepatic artery or by the portal vein. In the former case, the condition arises as a complication of general pyæmia of systemic origin; in the latter, the originating focus of mischief is located in the area of distribution of the portal vein—*i.e.*, in the intestinal canal. Thus, *pylephlebitis*, as it is termed, is not uncommonly met with in appendicitis, and sometimes in typhoid fever, whilst suppurating piles may also lead to it. It is characterized clinically by high fever, rigors, vomiting and abdominal distension; the liver is enlarged and tender, and the spleen may also be engorged with blood.

2. *Suppurative Cholangitis* is another cause of multiple abscess of the liver. It consists of an inflammatory affection of the biliary duct and passages, and is due to the spread of organisms from the

intestine, or occasionally from the gall-bladder after an operation. The biliary ducts in the liver become enormously dilated, and filled with a mixture of bile and pus which closely resembles yellow ochre. It is accompanied by pain over the gland and the general phenomena of pyrexia, but rigors are not present. The patient is not usually jaundiced, but bile may be found in the urine. Treatment is of little avail, but if a diagnosis can be made, and the gall-bladder has not been already incised, it may relieve tension to open and drain it.

3. Hydatid cysts may suppurate, and require treatment as for an abscess of the liver.

4. The more important abscesses, from a surgical standpoint, are those which, from their size, demand operative treatment. They may result from traumatism in the way stated above, or may arise in connection with hydatid cysts, but more commonly are of the type known as *tropical abscess*. The latter usually occurs in men who have travelled in the tropics, and 75 per cent. of the cases are attributed to dysentery. It is probable that unwise indulgence in alcohol is a predisposing factor, and that the abscess itself is embolic in origin. A large proportion of the cases are stated (by Dr. Leonard Rogers*) to be free from ordinary pyogenic organisms when first opened, but to contain in abundance the *Amœba coli*, which is looked on as being an important factor in the ætiology of dysentery. In the less acute cases the pus becomes sterile after a time, the organisms apparently dying. It is probable that in the more acute cases ordinary pyogenic cocci are usually to be found. A tropical abscess is most frequently situated at the back of the right lobe, but, of course, any part of the viscus may be involved. Though often single, the cavity is generally loculated, indicating that several original foci of suppuration have united together. The abscess wall consists of disintegrating hepatic tissue in acute cases, but may have a fibro-cicatricial wall in the more chronic forms, and in an old-standing abscess the limiting membrane may be as tough as leather. The pus is sometimes of the ordinary type, but not uncommonly reddish-brown in colour, somewhat like chocolate, and of a most nauseating odour.

The **Symptoms** are in some instances extremely slight, the patient perhaps dying of peritonitis due to its rupture without its presence having ever been suspected, or retaining the pus encapsuled for years. The individual usually complains of a sense of pain and fulness in the right hypochondrium, and in the more acute cases this may be accompanied by severe pain and localized tenderness over the whole hepatic region, the pain being also referred to the right shoulder. When the pus encroaches on the upper surface of the liver, a cough on taking a deep breath is rather characteristic. A certain amount of febrile disturbance occurs, the degree of which depends on the rapidity of formation of the abscess; in the more acute forms the temperature is high and rigors may be present; in the more chronic variety there is some fever in the evening, and night sweats occur. The pyrexial phenomena are associated with loss of appetite, rapid and well-marked emaciation, and perhaps a slight amount of icterus. On physical examination a more or less evident enlargement of the liver will be detected; but there is neither fluctuation nor a sense of elastic tension unless the abscess is very superficial. The dulness often extends up towards the thorax rather than downwards, though the contrary obtains when the abscess is situated not far from the free margin of the liver.

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* *British Medical Journal*, June 16, 1906

Left to itself, several distinct courses are open for the abscess to follow: it may become adherent to the anterior abdominal wall and point in the epigastrium, its onward passage being indicated by congestion and œdema of the parietes; it may open into the peritoneal cavity, or into one of the hollow viscera, such as the colon or duodenum; or, again, it may travel upwards, burrowing through the diaphragm, and either bursting into the lung, its contents being expectorated, or into the pleural cavity, leading to an empyema. Occasionally it remains passive as a chronic encysted abscess, and then the walls become very thick, as in a case operated on by one of us, which had been diagnosed by an exploring needle twelve years previously, and left alone. It contained about 2 pints of pus, and the walls were fully ½ inch thick. The patient came under observation because the swelling was becoming more prominent, as the result of increased intra-abdominal pressure, due to pregnancy.

In many cases the **diagnosis** of suppuration is by no means easy, and mistakes are likely to be made, the condition being looked on as one of hepatitis. A blood count may be of some assistance, and especially a differential count; but sometimes it is of little value, since a leucocyte count of 20,000 or more can occur without suppuration. A marked increase in the polynuclear leucocytes and a diminution in the small lymphocytes is always suggestive of the presence of pus, due to pyogenic organisms; in a pure amœbic abscess, leucocytosis occurs with a comparatively small increase of polynuclears. A doubtful diagnosis can sometimes be confirmed by the aspirator or exploring syringe, but this should not be utilized *unless one is fully prepared for immediate operation in the case of pus being found.* Manson directs that the aspirator needle should be introduced in the following situations: (1) In the right axillary line through the seventh or eighth costal interspace; (2) just below the ribs in the right nipple line; (3) immediately below the lung in the line drawn downwards from the angle of the right scapula.

Treatment.—It is unnecessary to discuss the medical treatment of cases of suspected abscess of the liver; but we must refer in passing to the diagnostic and curative value of ipecacuanha in the hepatitis that accompanies amœbic dysentery when pus is not present. Doses of 20 to 40 grains are administered once or twice a day twenty minutes after a small dose of tincture of opium, and if suppuration is absent the symptoms usually yield rapidly. When an abscess is present, operative treatment is of course necessary. *Aspiration*, repeated once or twice, has been frequently employed, but is of little value, and not a few cases are on record in which septic peritonitis or pleurisy followed the introduction of the needle from the front or side respectively. The practice usually followed is in accordance with the surgical law of treating suppuration—viz., that the abscess should be opened and drained. If pointing in front and adherent to the parietes, there is no difficulty or danger in making an incision over the most prominent spot and laying the cavity open; it is then well flushed out and a drainage-tube inserted. If on dividing the abdominal parietes it is found that the liver is not yet adherent, it was formerly thought best to plug the wound with sterilized or antiseptic gauze, or to introduce sutures between the liver and the parietal peritoneum so as to determine the formation of adhesions to such an extent as to shut off the general peritoneal cavity; in a few days the abscess could then be opened with safety. At the present time the operation is usually done at one sitting, with precautions similar to those taken in dealing with an intraperitoneal abscess connected with appendicitis. The general serous cavity must be carefully protected by sterilized gauze before letting out the pus, which is of course done slowly, and the assistant must keep the parietes in close contact with the hepatic tissue. It may be possible to insert a few stitches through the liver substance, securing it thus to the parietal peritoneum; otherwise one must trust to careful packing. After opening the abscess, it is usually advisable to wash it out, and this may with advantage be repeated subsequently. A large drainage-tube is inserted, and packed around with gauze to prevent purulent extravasation.

When the abscess is in its most common situation, viz., the back of the right lobe, it is often most satisfactory to open it from the side; a similar proceeding is sometimes needed when an abscess has been opened from the front, and does not drain properly. An incision is made a little behind the mid-axillary line through the ninth or tenth intercostal space, and a portion of one of the adjacent ribs removed. The pleural cavity is opened, and the costal pleura stitched carefully to that portion which covers the diaphragm; it will be found that this structure lies nearly vertical in this position, and but little difficulty is experienced in shutting off the general pleural cavity. The diaphragm is then divided, and not unfrequently the peritoneal cavity is opened; it must be carefully protected by gauze packing, and then the liver incised; less commonly adhesions may have already formed, or a bare area of the liver may be found, through which the pus can be withdrawn and the abscess opened.

Recently, however, some doubt has been thrown on this practice by Dr. Leonard Rogers,* who finds that the *Amœba coli* is easily killed by comparatively weak solutions of quinine, and hence has suggested that in amœbic abscesses all that is needed is to empty the cavity by aspiration, introduce 30 or 40 grains of bi-hydrochlorate of quinine, and employ no drainage. The results hitherto reported have been most encouraging. A rapid microscopic examination of the pus must of course be made at the time, and if pyogenic organisms other than the amœba are found, the ordinary operation can be carried out.

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* *Op. cit.*

Hydatid Cysts occur in the liver more frequently than in any other part of the body. For general details as to the life-history of the *Tænia echinococcus* and the structure of hydatid cysts, see p. 233 They produce a localized painless enlargement of the liver, the cysts varying in size from a small marble to a child's head; the outline is well defined if superficial, but not so if placed deeply; the cavity is usually filled with fluid and daughter-cells. Fluctuation may be distinguished, and a hydatid fremitus or thrill (arising from the concussion of the contained daughter-cysts) may, it is said, be elicited on palpation. The diagnosis is easily made if the cyst projects from the lower border, but when deeply embedded in the organ it may be exceedingly difficult, and the tumour can only be distinguished with certainty from carcinoma or syphilis by the use of the aspirator, or preferably by an open exploration. The character of the fluid withdrawn from a hydatid cyst is at once conclusive, as it is of low specific gravity, viz., 1007 to 1009, slightly opalescent, with no albumen, and a trace of salt; the presence of scolices or hooklets is the pathognomonic feature.

Terminations.—The cyst may remain latent and innocuous, or may actually dry up and form a mass somewhat like wet mortar, owing to the death of the organism; or it may burst and be evacuated in different directions, with or without suppuration. Thus, it may open externally through the abdominal parietes, or into the peritoneal cavity, causing fatal shock and in many cases peritonitis; or into the stomach or intestines, spontaneous cure usually resulting; or it may penetrate the diaphragm, and the contents be expectorated, or set free in the pleural cavity, causing a rapidly fatal pleurisy. It has been known to open into the pericardium, or even into the hepatic veins, the contents then being impacted in the right auricle; in both cases immediate death resulted.

Treatment.—The best plan of dealing with a hydatid cyst is to lay it open either through the anterior abdominal wall, or through the costal parietes and diaphragm, to empty it of its contents, and if possible to enucleate the lining wall or endocyst, which is often but loosely connected to the fibrous ectocyst. This is usually accomplished at one sitting. Similar precautions as to protecting the peritoneum are taken as for an abscess. When the surface of the liver is exposed, it is advisable to puncture the cyst first with a trocar and cannula, so as to reduce the tension within it. It is then incised freely and the loose daughter-cysts removed. This is facilitated by flushing out the cavity with sterilized salt solution. The endocyst is removed either by enucleation with the fingers or a blunt dissector, or it may be possible to detach it by irrigation, the nozzle of the irrigator being inserted beneath it. If enucleation is completely successful, the lesion in the liver may be closed, and the abdominal wound sutured in the ordinary way without drainage (Hamilton Russell), dependence being placed on the aseptic organization of the blood-clot which fills up the cavity in the liver. If for any reason this seems undesirable, a gauze packing is introduced into the cavity, and healing by granulation is allowed to proceed. If, however, part of the lining wall is left, a drainage-tube must also be introduced, and the cavity subsequently irrigated at each dressing.

No attempt should be made to remove the fibrous ectocyst, as it is closely connected with the liver substance, and grave hæmorrhage might follow any interference with it.

Formerly *aspiration* and *electrolysis* were largely employed in the treatment of this affection. It has been found, however, that although a considerable percentage of cases could be cured in this way (more than a half), yet it was not unaccompanied by risk of peritonitis, and that recurrence was often observed. Moreover, some of the fluid not unfrequently leaked into the peritoneal cavity, and probably from the absorption of some toxic product present led to urticaria, and sometimes to even graver phenomena of poisoning. Electrolysis merely acts by producing a puncture of the cyst wall and consequent leakage. Both of these methods should be entirely discontinued.

A suppurating hydatid cyst is dealt with according to the same rules of treatment as hold good for abscess of the liver.

Tumours of the Liver are rarely primary. Angiomata, adenomata, and simple cysts have been described, but *primary* growths are more often carcinomatous in nature, and develop either as a large well-defined infiltrating mass, or as a small central tumour, with secondary nodules scattered around. Sarcomata are rare. *Secondary* tumours of the liver are common, and either arise by direct extension from the gall-bladder, or follow a carcinoma of the intestinal canal, especially of the stomach or large intestine, or perhaps may be a sequel of cancer of the ovary, uterus, or breast. The liver is also involved secondarily in melanotic disease of the skin or retina. In all these cases the organ becomes enlarged and its surface irregular, due to the projection of nodular masses of the growth; in cancer they are frequently more or less umbilicated. The simple growths are occasionally pedunculated, and may arise from the left lobe, and thus become amenable to surgical treatment. Pain is not generally a prominent symptom, but ascites and jaundice develop in malignant cases from pressure on the portal vein and biliary ducts in the portal fissure, and œdema of the legs may be caused by compression of the inferior vena cava.

Gummata are developed in inherited and acquired syphilis, and are of sufficient size to need careful diagnosis from the more serious growths which develop in the liver. They are single or multiple, and occur in the form of rounded yellowish avascular masses, tending to caseate, and surrounded by much fibrous tissue. Absorption is followed by considerable cicatrization, which leads to deformity. The diagnosis from secondary carcinoma is not always easy. The history of the patient must be carefully considered, and if any doubt arise the Wassermann reaction is tested. Carcinomatous growths have a hard umbilicated surface, if it can be felt, enlarge rapidly with marked cachexia, and early produce jaundice and ascites. Gummata are slower in their progress, do not generally affect the structures in the portal fissure, and may be associated with an enlarged spleen from lardaceous or gummatous disease. A course of antisyphilitic medicine will necessarily influence the case very decidedly.

Actinomycosis of the liver is usually secondary to an affection of the alimentary canal, particularly the appendix or transverse colon, or may be due to a direct spread of the infection. The liver is enlarged, and may be covered with adhesions. On section the affected area presents a trabeculated honeycombed appearance, which has been compared to a sponge soaked in pus. There is much fibrosis around, and the trabeculæ are markedly fibrous. The pus contains the characteristic granules of the fungus. The clinical history is that of an hepatic abscess, and the prognosis is bad. Treatment is as for the disease elsewhere (p. 193).

Affections of the Gall-Bladder and Biliary Passages.

The **Gall-Bladder** (Fig. 501, *GB*) is a pear-shaped sac lying under cover of the liver and projecting into the peritoneal cavity. Its average length is about 3 to 4 inches, and it is normally capable of holding about an ounce of fluid. When one remembers that the liver secretes about an ounce of bile every hour, it is obvious that its function as a biliary reservoir must be very limited; in fact, it is possible that in a state of health it does not contain bile at all, and that it merely acts as a pressure-gauge regulating the flow of bile into the intestine or secretes a mucoid fluid which dilutes the bile. An *enlarged* gall-bladder projects downwards and towards the umbilicus, constituting a rounded swelling which moves with respiration, and is almost always in close relation with the anterior abdominal wall; it is freely mobile from side to side, and has attained such dimensions that it has been operated on in mistake for an ovarian cyst. It is attached to the liver by reflections of the peritoneum, which vary somewhat in their insertion; as a rule, about a fifth of the circumference of the gall-bladder is in contact with the liver. The attachment is loose, and when once the right layer has been reached, it is easy to strip the gall-bladder from the liver. The cystic artery reaches it at some distance from the fundus. In a few cases the gall-bladder has a complete peritoneal investment, swinging loose from the liver on a mesentery, and in two cases one has seen serious colic develop apparently from this lax attachment, much in the same way as a long appendix can cause appendicular colic. Removal of the gall-bladder demonstrated the absence of stones and cured the condition. Such a condition may be termed *Gall-Bladder Colic*, to distinguish it from the biliary colic produced by gall-stones.

The **Cystic Duct** (Fig. 501, *CD*) is about 2 inches in length, or rather less, and is arranged more or less in a spiral fashion by the attachment of the peritoneum. It will ordinarily permit of the introduction of a No. 5 catheter, but probably in a healthy state the mucous membrane is in such folds that a probe cannot be passed along it. The **Hepatic Duct** (*HD*) is 2 inches in length, and is formed by the junction of the right and left ducts which issue from the liver at either end of the transverse fissure and unite together at a very obtuse angle. The duct passes down with the hepatic artery, and a little above the upper border of the first piece of the duodenum is joined at a very acute angle by the cystic duct. The **Common Bile Duct** (*CBD*) is about 3 inches in length, and takes a No. 7 catheter; one inch or more of it is to be found above the duodenal border, and then it dips behind the viscus; and after lying between the inner border of the gut and the head of the pancreas, it perforates the bowel obliquely (*X*), sometimes being distended just before its termination to constitute the ampulla of Vater, and into this the duct or ducts of the pancreas also open.

Rupture or Perforation of the Gall-bladder results from such injuries as blows, crushes, kicks, etc., whilst it may also be produced by penetrating wounds or bullets; occasionally it may follow ulceration from within, as from a large impacted gall-stone. Blood and bile are in consequence extravasated into the peritoneal cavity. Pure bile is sterile, but if any inflammation of the biliary passages has been present, organisms are sure to have found their way into the gall-bladder, and thus complications may readily ensue. If a considerable quantity of bile escapes suddenly into the peritoneal sac, acute peritonitis is certain to follow sooner or later, whether organisms are present or not; slight jaundice arises from absorption by the peritoneum of bile, which may also be found in the urine. A more gradual escape of the secretion will probably lead to the formation of a localized intraperitoneal abscess or collection of fluid, associated with jaundice and probably clay-coloured stools. In a penetrating wound bile and blood will escape on the surface, and septic peritonitis is almost sure to follow.

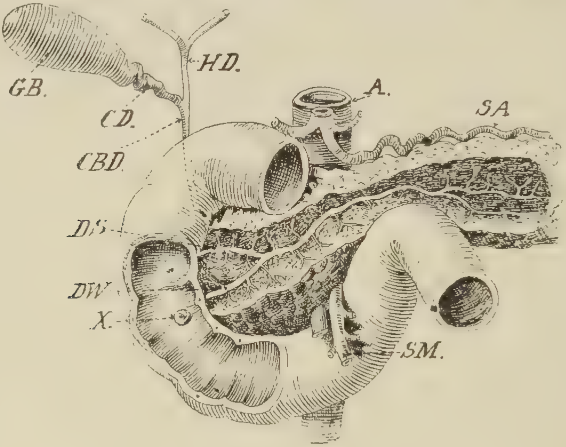


FIG. 501.—DIAGRAM OF THE BILIARY PASSAGES AND THEIR RELATION TO THE DUODENUM, WHICH HAS BEEN LAID OPEN, AND PANCREAS.

GB, Gall-bladder; *CD*, cystic duct; *HD*, hepatic duct; *CBD*, common bile-duct; *DS*, duct of Santorini; *DW*, duct of Wirsung; *X*, opening of common bile-duct and duct of Wirsung in the duodenum; *A*, aorta; *SA*, splenic artery; *SM*, superior mesenteric vessels.

The immediate **Symptoms** are those of shock and severe hypochondriac pain, and this will be succeeded either by acute peritonitis or by the formation of a localized intraperitoneal swelling, together with mild jaundice. When the existence of such a lesion is suspected, **Treatment** always consists in an exploratory laparotomy. The fluid within the abdomen is removed with swabs or washed away, and the gall-bladder carefully examined. Should only a small injury be found, it is perfectly feasible to close it by sutures; a gauze wick should, however, be passed down to the lesion for a few days, so as to provide a means of drainage, should leakage occur. A more serious rupture will necessitate removal of the gall-bladder. Should the common bile-duct be entirely divided, the ends should be closed by sutures and a cholecystenterostomy undertaken; a small wound in the duct may be sutured.

Inflammation of the Biliary Passages is of frequent occurrence, and generally arises as a sequela of a gastro-duodenal catarrh. The affection is similar in nature to that commonly seen in other tracks lined with mucous membrane, and may be limited to the main bile-ducts and their extensions into the liver (*cholangitis*), or may also involve the gall-bladder (*cholecystitis*). The catarrh is determined by the presence of micro-organisms, and streptococci, staphylococci, or the *B. coli*, are most frequently present; the condition may be limited to a simple catarrh, or suppuration may follow.

Catarrhal Cholangitis is more of medical than of surgical interest, but its frequency and its ætiological connection with the development of gall-stones warrants its introduction into a surgical text-book. In the *acute* form it is common in young people, arising from over-eating or injudicious food, combined perhaps with exposure to cold and wet. The patient feels ill, perhaps shivers, looks a little sallow, or maybe is actually yellow (*catarrhal jaundice*). Abstinence from all but fluid food, and the administration of mild purgatives, especially of the saline type, will generally free the patient from his symptoms in a very short time.

Sometimes the condition is of a more *chronic* type, occurring then in people of middle life, who are the subjects of persistent dyspepsia, often caused by late hours, irregular and injudicious meals, constipation, and perhaps mental and nervous tension. Indulgence in alcohol adds to the trouble. Such people are frequently 'livery,' and look more or less sallow, but are not actually jaundiced; they lose weight, and are irritable to a degree; but none of the graver symptoms of malignant disease are to be found. The liver is probably a little enlarged and may be tender, and the gall-bladder may be palpable. It is this type of patient in whom gall-stones are liable to develop, and for whom courses of waters do so much good, as at Carlsbad or Harrogate, where hydro-therapeutic measures are combined with a rigid dietary. The essential elements of the treatment can be quite well carried out at home if the patients will submit to the restrictions that must be enforced.

Infective Cholangitis is a much more serious affection, and may lead to a fatal issue. It is usually due to the presence of a stone or stones in the common bile-duct, but may arise from other causes, *e.g.*, ascarides or hydatid cysts which have escaped into the biliary passages, from malignant disease, or it may spread backwards into the liver from a suppurating gall-bladder. The general phenomena which follow an attack of biliary colic, due to the attempted or successful passage of a gall-stone, are due to this cause, and hence fever with or without a shivering fit, a certain amount of jaundice (which is easily comprehended when one remembers the low pressure at which the bile is secreted), enlargement and tenderness of the liver are to be looked on as the characteristic features of a mild attack. *Treatment* necessarily consists in removal of the cause, if possible, or, failing that, in draining the biliary passages by cholecystostomy. It must not be forgotten that the persistent presence of such a condition may lead not only to mischief in the liver, but also to chronic pancreatitis, and to adhesive peritonitis, which may complicate future operative procedures, and therefore in any patient with well-marked symptoms operation should never be delayed too long.

In the more serious types of this affection suppuration may extend up the passages and lead to multiple abscesses in the liver, a condition already noted at p. 1061. Drainage of the gall-bladder and removal of the causative stones is the only hope of cure, but the prognosis is very grave.

Cholecystitis, or inflammation of the gall-bladder, is most commonly the result of the presence of stones in that cavity, but may also arise as a sequela of typhoid fever. Indeed, the *B. typhosus* seems to have a special predilection for this viscus, and may reside there for years after the primary attack, the individual or typhoid carrier being thus a danger to the community from his ability to discharge living organisms at intervals. Streptococci or staphylococci are present in the other cases, with or without the *B. coli*.

There is nothing specially noticeable about the pathological phenomena, except that the viscus is intraperitoneal, and that there is some analogy between the troubles arising here and in the appendix. There is, however, less tendency for the peritoneum to be seriously involved owing to the greater thickness of the wall, and its greater capacity for stretching; thus a distended gall-bladder may contain a large quantity of muco-pus without giving way, and the viscus has even been opened in the pelvis or through the sac of a hernia. Protective adhesions frequently develop between the gall-bladder and the stomach, duodenum or transverse colon, and not a few of the uncomfortable symptoms produced by gall-stones are due to their existence.

The *clinical history* varies according to whether the condition is chronic or acute. In the *chronic* variety produced by gall-stones, the symptoms are part of the syndrome characteristic of that condition, and are but little noticeable in themselves. The gall-bladder may be enlarged, and a little tender on pressure; should the cystic duct be blocked, it will be distended with mucus or muco-pus according to the degree of irritation present. The *acute* form is evidenced by marked pain and tenderness in the right hypochondrium, together with vomiting, constipation, and fever. The constipation may be very marked, as it is due to paralysis of neighbouring coils of intes tine, and especially the transverse colon. The abdominal wall is held rigid, and the right rectus is very tense; but the enlarged gall-bladder can usually be detected beneath it. In one case it was as large as a cocoa-nut, and on exposure was of a brilliant red colour, and contained about 8 ounces of muco-pus; it was absolutely free from adhesions and contained two gall-stones, one of them embedded in the œdematous wall and near the point of perforation. As a rule, a sufficiency of adhesions forms to protect the general cavity of the peritoneum, and then the abscess, if unrelieved by art, may burst into the bowel, or may open externally and discharge itself. In the most severe forms sloughing and gangrene of the wall follow (*phlegmonous* or *gangrenous cholecystitis*), and then general peritoneal infection may ensue. In the milder forms the inflammation may in time subside, the gall-bladder emptying itself *per vias naturales ;* but adhesions of a more or less severe character are likely to be left and may cause much trouble, whilst the gall-bladder itself may shrink and atrophy.

Treatment consists in dealing with the cause, if such be gall-stones. In the acute variety of suppurative inflammation, the gall-bladder should be removed without delay, just as one removes an inflamed appendix. There are frequently many newly formed omental adhesions, but it is not difficult as a rule to clear the gall-bladder and excise it completely. Only if there are dense adhesions of old standing is it necessary to open it, remove the contained stones, and drain it. The operations are described below, and need no special reference.

Cholelithiasis is the term applied to the presence in the gall-bladder or biliary passages of **Gall-stones.** These consist mainly of crystals of cholesterine, held together by mucus and coloured by the bile-pigment; they are soluble in chloroform. When first passed and moist, their specific gravity is a little higher than that of water, and hence when immersed in it they sink; after drying, however, they are found to float. The number present varies immensely; sometimes a single large one exists, which is more or less barrel-shaped (Plate IX.); more frequently they are multiple, scores or hundreds being present, and are then usually faceted, and with a satin-like yellowish lustre. If they have lain long in the gall-bladder, they are usually of a deep brown or almost blackish colour.

The **Origin** of gall-stones is not yet fully understood, but there seems no doubt that they are primarily due to a chronic catarrhal affection of the gall-bladder or biliary passages, the cholesterine being formed by the lining epithelium. The original trouble is probably a gastro-duodenal catarrh, and the inflammation spreads upwards from the bowel to the gall-bladder. Gall-stones usually develop in the gall-bladder or the lower biliary passages, but they can also form in the ducts within the liver, especially in cases where the hepatic derangement has been of long standing. They occur most commonly in women who have suffered from dyspepsia and constipation, and may be associated with cancer, either as cause or effect. In one case the origin of the trouble seems to have been the swallowing of a pin many years previously, which worked its way into the gall-bladder, set up an inflammation, which resulted in the formation of calculi, and only appeared again after a successful operation, when sixty-six stones had been removed.

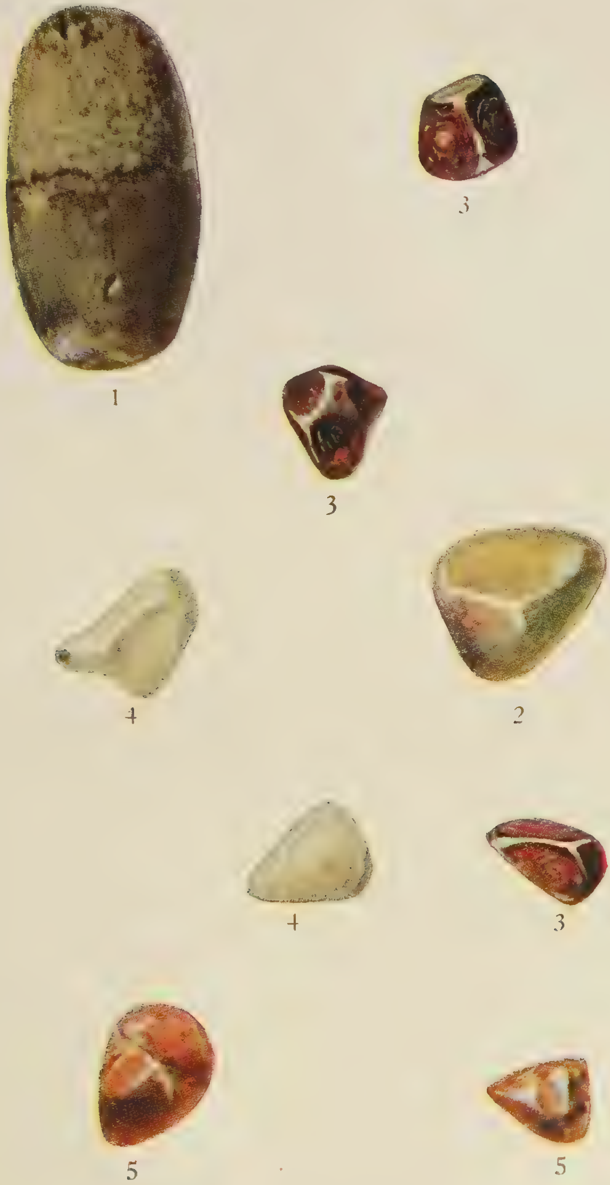
The fact that gall-stones are frequently found unexpectedly on the operating-table or in the post-mortem room suggests that they may remain quiescent for years, and only cause trouble when attempting to escape, or if associated with some inflammatory disturbance. Thus the first evidence of their presence may be an attack of acute suppurative cholecystitis, and then, unless prompt attention is given, diffuse peritonitis may result. Sometimes they cause chronic irritation of the gall-bladder, resulting in the walls becoming thickened and hyperæmic at first, but subsequently white and opaque; and in time a process of sclerosis supervenes, which may lead to contraction of the wall upon the stones which are thereby encapsuled, and all attempts to displace them come to an end; cancer may also supervene. Adhesions also form between the gall-bladder and surrounding tissues, and thereby the movements of the pylorus or transverse colon may be hampered. More frequently the gall-bladder contains enough fluid to keep its walls distended, and then efforts to expel the stones follow, giving rise to definite painful symptoms. Sometimes the stones slip back; at others they pass on and may escape into the bowel, or may be blocked in the cystic or the common bile-duct, and find it impossible to progress further. Such stones may ulcerate through into various viscera, such as the stomach, duodenum, or colon, and thereby relief be given to the symptoms, or they may escape into the general peritoneal cavity and cause peritonitis.

The **Clinical History** of a case of cholelithiasis is obviously very variable according to the exact location and condition present.

1. In what has been termed the *Prodromal Stage*, when the stones are free in the gall-bladder, and not doing much harm, the symptoms are referable rather to the stomach than to the hypochondrium. The patient complains of a sense of weight and fulness in the epigastrium, particularly after meals, accompanied by flatulent distension, which is relieved by belching, or entirely removed by vomiting. This may have lasted for years, and is usually accompanied by constipation. Sometimes the discomfort amounts to acute pain, which doubles up the patient, and may be more severe on taking a deep inspiration. With these phenomena there may be a sense of chilliness scarcely amounting to a rigor, and when the pain passes the patient may perspire. He is often a little sallow, especially on days when he feels bilious, and there is some tenderness over the gall-bladder; but the diagnosis of gall-stones is scarcely warranted unless the pain is very acute. Unfortunately, radiography does not often help in the diagnosis.

2. When the gall-stones are loose in the bladder and attempting to escape, more definite and distinct phenomena result. *Pain* is perhaps

PLATE IX.



Various types of Gallstones (natural size).

Fig. 1 is a large barrel-shaped stone removed with the gall-bladder, in which it was firmly held. *Fig* 2.—An ordinary gallstone of moderate size. *Fig* 3. Dark gallstones, evidently old inhabitants of the gall-bladder, and deeply stained with bile-pigment. *Fig.* 4. —More recently-formed gallstones with but little bile-pigment, and one on section showing lamination. *Fig.* 5. Bright brownish stones with facets.

[*To face page 1072.*

the most marked feature, and may be of various types. (*a*) There is the localized pain, due to the irritation of the gall-bladder itself, which is rather a dull ache referred to the right hypochondrium, shooting through to the back about the level of the tenth rib, and perhaps up to the right shoulder; this form is usually increased on movement. (*b*) Pain is also complained of, due to the adhesions which form about the gall-bladder, and hamper the movements of the stomach or intestine; this is often epigastric in location, and may be of a colicky nature, especially after meals. (*c*) The worst pain is the typical *biliary colic*, due to the efforts of Nature to expel the stones. This is often of an excruciating character, starting suddenly, continuing for a while, and often ceasing as suddenly as it commenced when the stone passes on or slips back; the patient may be collapsed owing to its severity. It radiates from the right hypochondrium, shooting over the scapular region and into the back; the gall-bladder may be enlarged and tense during the attack, and the liver somewhat swollen. Vomiting occurs during or after an attack of biliary colic, especially when adhesions to the stomach or duodenum are present. Jaundice is not usual except after an attack of biliary colic, and is then due to the swelling of the mucous lining of the biliary passages, preventing the escape of bile; if the stone slips back, it is not so likely to occur. The presence of many loose gall-stones usually determines an enlargement of the gall-bladder, which can be felt from the outside.

3. *Impaction* of a stone *in the cystic duct* is characterized by pain, which is more or less persistent, but with paroxysmal exacerbations, and the gall-bladder becomes distended with its own mucoid secretion (*hydrops*), until it may attain a considerable size. Jaundice is usually absent. Not uncommonly acute inflammatory phenomena follow (acute suppurative cholecystitis), and this may lead to ulceration or perforation. Less frequently chronic suppuration occurs, constituting an *empyema* of the gall-bladder.

4. Occasionally a stone becomes lodged at the junction of the cystic and the hepatic ducts, and then the manifestations of obstruction are very severe, and the pain may be very acute. Icterus is intense, but the gall-bladder may be empty; the liver is certain to be much enlarged.

5. The presence of gall-stones *in the common duct* may give rise to symptoms of the most diverse type; a small stone may originate very severe phenomena, whilst a much larger stone may cause less trouble. Frequently several stones are present, and sometimes they are embedded in a mass of soft 'biliary mud,' consisting of inspissated bile salts. Their location, too, varies considerably; a single stone is perhaps found most frequently in the lower part of the duct, whilst multiple stones involve its whole length. The symptoms caused are pain of a paroxysmal character accompanied by vomiting, and jaundice, sometimes of a severe type, occasionally less marked, but rarely as persistent as the jaundice due to malignant disease. The stone is more or less moveable, and acts as a ball-valve, at times

allowing a certain amount of bile to pass. In malignant disease the obstruction is absolute, and the jaundice is thereby maintained. The liver is enlarged owing to back pressure of bile, but the gall-bladder does not participate in this distension, whereas in malignant disease or other causes of persistent jaundice it is often dilated to a considerable degree (Courvoisier's law). If the stone is located in the ampulla of Vater, it is easy to understand that pancreatic troubles are likely to be associated with the jaundice, but it may ulcerate into the duodenum without much difficulty. Should a perforation form posteriorly, the retroperitoneal cellular tissue becomes involved, and a subphrenic abscess may result.

The **Treatment** of gall-stones is, in the first place, medical in character, and consists in a rigid attention to the diet which should be simple and easily digestible; this is accompanied by regular exercise and the use of alkaline purgatives of a saline character and an abundance of pure water. This is best carried out at a spa such as Harrogate or Carlsbad, but can be arranged for at home, if the patient will submit to the necessary regulations. Biliary colic is treated by fomentations, and if need be by an injection of morphia; it is perhaps wise to administer salol or some other intestinal antiseptic, whilst salicylate of soda assists in increasing the fluidity of the bile. It is quite an arguable question as to what happens in such cures, whether the stones are softened and passed, or whether they become acclimatized in the gall-bladder and cease to cause trouble. At any rate, it is important not to waste too much time in this direction, should the symptoms persist. It has been already pointed out that gall-stones are not to be looked on as perfectly innocuous; inflammatory troubles of a serious character and even malignant disease may be caused by them, and therefore the persistence of symptoms, and especially their aggravation, indicates the necessity for surgical interference. The proceedings required vary somewhat according to the location of the stones, and different operative measures have been devised in order to deal effectively with these varied conditions.

It must be remembered that the existence of gall-stones is an evidence of chronic inflammation of the lining mucous membrane of the gall-bladder, and that the mere presence of the stones maintains and increases this irritation so that the walls are usually in a sclerosed or thickened condition. The simple removal of the gall-stones does not necessarily cure the inflammatory trouble, and hence recurrence is by no means uncommon; moreover, the sclerosed wall of the gall-bladder freed from irritation often contracts down, and the result is that the organ becomes shrunken and functionally useless. Hence in a large percentage of cases it is useless to attempt to save the gall-bladder, and the general rule of treatment is that when it is probable that recurrence of gall-stones may be expected or the functional value of the gall-bladder destroyed, *complete excision* of the organ and of the contained stones should be undertaken. Cholecystectomy is also indicated when a stone has been firmly impacted in the cystic duct; a stricture in that position is almost certain to follow the removal of the stone, and hydrops or empyema of the gall-bladder will result. In acute cholecystitis of calculous origin, excision is usually desirable, as also in the more chronic suppurating cases.

Incision with removal of the stones and subsequent suture of the gall-bladder (*cholecystendysis*) is occasionally permissible, but only when the calculous history is insignificant, or when a gall-stone is discovered by accident during an abdominal operation. Drainage is probably unnecessary in the majority of cases where the gall-bladder wall is tolerably healthy.

In cases where the symptoms have not been very severe, but the patient has suffered for some time from pain and recurring 'bilious' attacks, and looks sallow and slightly jaundiced, and yet on exploration the gall-bladder is free from adhesions and not much altered in its structure, it may be wise to drain it for a while after removing the stones (*cholecystostomy*) rather than to excise it. The flow of bile relieves the hepatic congestion, and improves the condition of the patient. Moreover, calculi in such cases sometimes develop in the biliary passages higher up, and an opportunity for the escape of these is thereby afforded. A drainage-tube is placed in the fundus of the gall-bladder and secured by catgut stitches, which are dissolved in about a week and set the tube free. The flow of bile usually persists for another week or two and then ceases, the wound in the gall-bladder closing by granulation when the wound is packed. Should it, however, continue for any length of time, further operative measures in the direction of closing the opening in the gall-bladder by invagination of the margin and over-stitching will be required, or the organ is removed completely and the cystic duct ligatured.

Impaction of a calculus in the cystic duct usually necessitates excision of the gall-bladder, inasmuch as a stricture of the duct is almost certain to follow incision and removal of the stone. Should it, however, be fixed close to its junction with the common bile-duct, it may be better to free the gall-bladder and remove it by dividing the cystic duct on the distal side of the stone, which is then extruded by digital pressure or delivered by a scoop. The biliary passage may then be drained for a while, or the duct closed by ligature or suture.

A stone in the common bile-duct is removed by exposing and incising the duct (*choledochotomy*). There is but little difficulty in effecting this if the stone is in the upper part above the duodenum; the stone is localized and fixed, and the duct incised longitudinally over it. The peritoneum is guarded by suitable swabs, and the stone is then removed. Careful examination should be made both upwards to the liver and down to the intestine by a probe to make certain that no further stones are present. If a stone is lodged behind the second piece of the duodenum, it may be possible to manipulate it up, and make it accessible above the intestine; but otherwise the duodenum must be mobilized by dividing the peritoneum on its outer edge. It can then be displaced inwards sufficiently to enable the dilated duct and stone to be reached from the outer side. In both of these operations an effort may be made to close the ducts with sutures which do not encroach on the mucous membrane; but it is probably wiser to introduce a drainage-tube into and up the duct for a few days so as to relieve the engorgement of the liver, which is certain to be present. These wounds usually heal quite satisfactorily.

In a few cases, when the stone is lodged in the lowest portion of the duct, it may be necessary to incise the duodenum longitudinally front and back, and, after extracting the stone, to make a fistula between the duct and the posterior wall of the intestine (*internal choledocho-duodenostomy*). An impacted stone should never be left *in situ*, as, although it may pass at the end of a few days or weeks, it will cause much pain, and before becoming dislodged it may do much harm, not only to the biliary apparatus, but also to the pancreas.

Operations on the Biliary Passages.—No special preparation of the patient is required, although some surgeons recommend that in cases which have been long jaundiced it is wise to give 20 or 30 grains of lactate of calcium *per rectum* once or twice previously, so as to lessen the bleeding, which has a tendency to persist; one's own personal experience does not confirm this statement.

It is wise in all operations on the biliary passages to introduce a firm sandbag horizontally beneath the patient's back, so as to throw the liver forwards, and thereby gain better access to the deeper parts.

The incisions suggested vary somewhat, but that usually employed is a vertical one, 3 or 4 inches in length, to the outer margin or through the substance of the rectus; this would suffice if the gall-bladder is merely to be emptied of stones, and is easily accessible. But when it is tied down by adhesions to the under surface of the liver, or has to be completely excised, or when the common bile-duct has to be explored or opened, a more extensive approach will be required, and this is gained by carrying the vertical incision inwards parallel to the costal margin and about 1½ inches from it, extending across the rectus muscle to the middle line if necessary (Fig. 473, *B*). It has recently been recommended by Perthes* that the incision should be made close to the middle line, extending from the ensiform cartilage nearly to the umbilicus, and then crossing the rectus horizontally outwards to the margin of the ribs. The fibres of the rectus muscle are secured by mattress sutures to the anterior layer of the sheath above and below before being divided so as to prevent retraction, and the rectangular flap of skin and muscle is then dissected up off the posterior layer of the sheath and peritoneum, which are divided by an oblique incision. The main object of this procedure, which gives an admirable approach to the biliary passages, is to avoid division of the nerves supplying the rectus muscle. It may be employed with advantage except in cases where drainage is likely to be necessary.

The peritoneum being opened, the liver is drawn upwards and outwards and the intestines, stomach, and omentum downwards and inwards after protecting them by abdominal cloths. In the absence of adhesions, the object of the operation can usually be attained without much difficulty, but not unfrequently the presence of adhesions complicates matters considerably; they must be carefully divided with a view to preventing subsequent hæmorrhage. If the gall-bladder is much distended, it is sometimes necessary to tap it and empty out its contents before a decision as to diagnosis or treatment can be reached. Care must be taken not to allow the peritoneum to be soiled by the escape of bile, mucus, pus, or stones, which are almost always infected.

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* M. W. Gray, *British Medical Journal of Surgery*, October, 1913, p. 200.

For **cholecystendysis,** the trocar puncture is enlarged by the knife, and the stone or stones removed by forceps, scoop, or by digital extrusion, and then the opening is closed by sutures which do not encroach on the mucous membrane. One or two rows of stitches may be employed according to the condition of the gall-bladder wall, and it may be wise to strengthen the site of union by an omental graft. For **cholecystostomy,** a medium-sized drainage-tube without lateral openings is stitched into the gall-bladder by catgut sutures, which should last about a week. The gall-bladder is then fixed to the parietal peritoneum, and the remainder of the wound closed. It is often wise to protect the abdominal cavity from leakage by packing off the gall-bladder area. The outer end of the tube is passed into a bottle lying by the patient's side, in which the bile collects. When the tube becomes loose, the wound is lightly packed with gauze, and for a time the patient's condition is uncomfortable, as the bile escapes into the dressings, which must be frequently changed. As, however, the wound granulates, it becomes more difficult for the bile to escape externally, and more easy for it to follow its natural course, and hence after two or three weeks the external flow usually ceases, and the wound may be allowed to close. Should, however, the escape of bile persist, further treatment becomes necessary. If the presence of a certain amount of bile in the motions indicates that the common bile duct is free from obstruction, the opening in the gall-bladder may be completely closed by sutures after freeing it from adhesions. The absence of bile in the stools, however, suggests the presence of some stricture or obstruction in the bile-duct, and if this cannot be dealt with, cholecystenterostomy must be undertaken.

Cholecystectomy, as already mentioned, is the operation of choice in the majority of cases of gall-stones. It is usually not a difficult procedure, and the mortality is small. The serous coat is divided on either side and over the fundus about a centimetre from its reflexion from the liver, and a line of cleavage is generally found without difficulty between the capsule of Glisson and the body of the viscus. It is then easy to separate it from the liver; the cystic vessels are secured by ligature, and finally the cystic duct is tied and divided. If possible, the peritoneal coat is drawn together over the gap left by the removal of the gall-bladder, but it is usually necessary to pack this space with gauze for a few days.

Cholecystenterostomy, or the formation of an artificial communication between the gall-bladder and the bowel, is required in cases where jaundice persists, owing to absolute stenosis of the common duct. It has also been undertaken for the relief of jaundice due to malignant disease, either of the common bile-duct, the head of the pancreas, or of the intestine; the relief given under these circumstances is, of course, only temporary. The parts are exposed as described above, the gall-bladder and duodenum are brought into contact, and a lateral anastomosis made by simple suturing by a technique similar to that employed for a lateral anastomosis of the intestine.

Tumours of the Gall-bladder and Biliary Passages are usually malignant, and of a columnar carcinomatous type; benign tumours are very rare, and merely of pathological interest. Cancer is comparatively common, and is so constantly associated with gall-stones (some authorities state that 90 to 95 per cent. of such cases also have gall-stones) as to suggest that the irritation of the latter may induce the neoplastic formation. The disease is about three times as common in women as in men. Cancer of the gall-bladder usually commences near the fundus and spreads upwards. The symptoms and signs are those of a hard, painless swelling in the region of the gall-bladder, with progressive loss of weight and later on jaundice and ascites. Primary cancer of the common bile-duct is rarer, and causes jaundice, without pain, as an early symptom, together with distension of the gall-bladder. The jaundice is persistent, and gradually increases in severity. Gastric symptoms from pressure of the growth on the pylorus or duodenum may follow, and extension in various directions may determine different manifestations. In either of these affections lymphatic dissemination along the falciform ligament may lead to the appearance of a secondary nodule in the region of the umbilicus, which may be of diagnostic import.

Treatment is rarely practicable, as the disease is usually recognised too late. Excision of the gall-bladder, and, if need be, of the neighbouring portion of the liver, may be practicable in a few cases; for tumours of the common bile-duct, excision is usually impossible, but cholecystenterostomy may relieve the intense jaundice and add to the patient's comfort.

Affections of the Pancreas.

The pancreas is a glandular organ which secretes an active digestive juice, which escapes into the intestine through the duct of Wirsung (Fig. 501, DW), which traverses the whole length of the gland, and opens with the common bile-duct into the ampulla of Vater; a small accessory duct of Santorini (DS) opens into the bowel about an inch higher up. The pancreas has only recently received much attention from surgeons; its depth and anatomical relations explain the neglect with which it was treated for so long. At the present time its affections are being studied with a keen interest, and considerable operative activity is being directed towards it. There are two chief methods of approaching it: (1) The transperitoneal, in which the abdomen is opened in the middle line above the umbilicus; the gland is reached either above the stomach by dividing the small omentum, or by traversing the great omentum just below the great curvature of the stomach, or by opening through the transverse meso-colon. (2) The retroperitoneal method consists in an incision below the last rib in the lumbar region, but only the head or the tail is exposed by this procedure.

There are two chief risks associated with pancreatic lesions or operations: (i.) The organ is very freely supplied with blood, and it is extremely difficult to ensure hæmostasis. Ligature of the pancreatic tissue causes necrosis, and from the necrotic tissue ferments are set free which act injuriously on the tissues around, and predispose to further hæmorrhage. Deep stitches and effective tamponade can alone be relied on in this direction. (ii.) The leakage of pancreatic juice is a serious danger to the patient in that it is likely to determine necrosis of fat wherever it spreads; hence foci of fat necrosis may be found scattered extensively through the omentum and mesentery in all acute pancreatic lesions. Moreover, it acts most prejudicially on the peritoneum, and induces either an aseptic peritonitis and intestinal paralysis which may prove fatal, or determines an infective peritonitis if bacteria are present.

Wounds of the Pancreas are due to direct violence applied to the epigastrium, and may result from penetrating or non-penetrating injuries. They are usually accompanied by lesions of other viscera, such as the stomach or duodenum, and surgeons should remember the necessity for examining this viscus in any traumatic condition in the neighbourhood. Deep sutures and tamponade must be used in all cases where solution of continuity has occurred, the latter being needed not only as a hæmostatic agent, but also in order to drain away any leakage of pancreatic fluid. Prolapse through an abdominal wound has been recorded in a few cases, the organ having been almost entirely separated from its connections; however bruised or damaged, its total extirpation must never be resorted to, since diabetes is certain to follow; it should therefore be carefully purified and replaced.

Acute Pancreatitis is a grave affection, frequently fatal, and not uncommonly mistaken for acute obstruction until diagnosed on the operating or post-mortem table. It may follow an injury, and is then due to an interstitial hæmorrhage, which gradually increases; a similar hæmorrhage sometimes appears spontaneously in alcoholic subjects, and is termed a ' pancreatic ' apoplexy; it is quite possible for such cases to run an acute course and even prove fatal without infection. More usually the condition is infective, the bacteria reaching the gland from the intestine, or is determined by regurgitation of bile owing to the impaction of a biliary calculus in the ampulla of Vater. Pancreatic calculi also occur, and may light up an attack of acute pancreatitis; they are usually small and elongated, consisting mostly of carbonate of lime. The organ becomes enlarged, thickened, and congested; purulent foci are scattered here and there through it, and in and around it are found necrotic spots due to the action of the pancreatic secretion. Sometimes the whole gland or a large portion of it has been known to slough. An inflammatory effusion develops in front, which is usually purulent and sometimes hæmorrhagic; it may be limited to the lesser sac of the peritoneum, then following the lines of a subphrenic abscess, or it may involve the general peritoneal cavity.

The **Symptoms** vary much, but usually start suddenly with acute epigastric pain, which soon becomes excruciating. This is accompanied by nausea and sickness, by constipation and abdominal distension, and by a serious collapse which may quickly prove fatal. The pain is due to the swollen organ pressing on the cœliac plexus of nerves. The swelling of the abdomen commences in the epigastrium, and may for a time be limited to that region, but subsequently the phenomena of acute diffuse peritonitis may supervene. Occasionally the trouble quiets down at the end of a few days, but much more frequently it is fatal. The **Diagnosis** usually made is that of acute obstruction, or acute generalized peritonitis, and the true nature of the case is only recognised on opening the abdomen. **Treatment** consists in laparotomy and giving an exit to the inflammatory exudate. If diffuse peritonitis is present, the abdominal cavity must be opened above and below and irrigated, and the local trouble exposed; dead pancreatic tissue should be removed, and effective drainage provided. If a localized abscess forms, the greatest care must be taken to guard against a generalized infection. Posterior drainage is advisable in all these cases.

Chronic Pancreatitis is not to be looked on as a very uncommon lesion. It is frequently associated with gall-stones and inflammation of the biliary passages, and may follow gastro-duodenal catarrh or ulceration. The organ becomes harder than usual, or is shrunken and sclerosed. It may produce a swelling in the epigastrium which is likely to be mistaken for a pancreatic carcinoma, or the symptoms may be mainly of a dyspeptic type. Fixed epigastric pain is often present, and a tender spot a little above the umbilicus. Diabetes may arise in certain forms of chronic inflammation; offensive diarrhœa with undigested fat in the stools and rapid wasting are also suggestive symptoms. Operative treatment may be of value, since pancreatic or biliary calculi may be found obstructing the duct; apart from this, benefit has certainly been derived by cholecystostomy and drainage of the biliary passages.

Cysts of the Pancreas have been observed and treated in so many cases since 1887 that their characters are pretty clearly known. Simple complete obstruction to the duct has been proved experimentally not to be a sufficient cause for the disease; some pathological condition of the epithelium must also be present, preventing the re-absorption of the retained secretion. Slight traumatism is not an uncommon cause, and a cyst may develop as a sequela of an attack of inflammation which has quieted down. The fluid within is usually turbid, and brownish from admixture with blood, odourless, and with a fairly high specific gravity; it is of an alkaline or neutral reaction, and contains albumen, but no urea or bile; it is capable of peptonizing albumen, of emulsifying fat, and of converting starch into sugar. The cyst can be felt as a rounded, tense, fluctuating or elastic swelling, placed deeply in the abdomen, immoveable, and perhaps transmitting the aortic pulsation. The relations of a cyst to the stomach and transverse colon vary (Figs. 502-504); the cyst primarily forms behind the stomach, but when it attains any considerable size it projects anteriorly, and then most commonly approaches the abdominal wall below the stomach and above the transverse colon (Fig. 503). More rarely it presents above the stomach (Fig. 502), or below the transverse colon (Fig. 504). Pancreatic cysts usually develop in middle life, occurring most frequently in men. Emaciation is sometimes marked, since a good proportion of the fatty food passes away in the motions; the skin is often dirty, earthy, and unhealthy-looking.

Treatment consists in laying the cyst bare, the surgeon usually finding his way to it between the stomach and transverse colon. Its contents are then drawn off by trocar and cannula, and arrangements made for drainage. A large tube is inserted, either through the front, or from the back by the side of the vertebræ. The skin around usually becomes irritated by the discharge, owing to a process of digestion. The prognosis with such treatment is good, although healing may be slow, and a permanent fistula may develop. Körte collected 101 cases operated on, and of these 5 died, 4 from the the direct result of the operation, 1 from infection of the fistula.

Carcinoma of the Pancreas is met with either as a primary growth of a spheroidal-celled type, usually scirrhus, or is secondary to a similar disease of the stomach or pylorus. The condition is not necessarily painful in the early stages, and produces an ovoid or oblong mass at the junction of the epigastric and right hypochondriac regions. As it develops, it becomes more painful, and the patient quickly wastes and loses appetite and energy. Jaundice gradually supervenes, and becomes absolute, with an enlarged gall-bladder; the abdomen is distended with fluid from pressure on the portal vein, and the legs may become œdematous from involvement of the inferior vena cava; whilst the growth may lead to distension of the stomach from pressure on and constriction of the pylorus. In one or two cases removal has been undertaken with success, although an exact diagnosis was not arrived at before the operation. Sarcomata and other tumours are very rare.

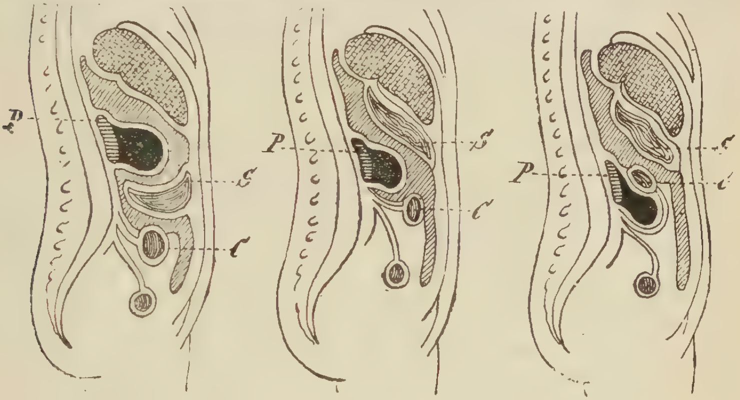

FIG. 502. FIG. 503. FIG. 504.

FIGS. 502–504.—DIAGRAMS TO REPRESENT THE VARYING RELATIONS OF PANCREATIC CYSTS.

In Fig. 502 the cyst (*P*) projects forwards between the stomach (*S*) and liver into the lesser peritoneal sac, presenting through the lesser omentum. In Fig. 503 the cyst is located below the stomach, projecting forwards between the stomach and the transverse colon (*C*). In Fig. 504 the cyst lies lower, between the transverse colon above and the small intestine with its mesentery.

Affections of the Spleen.

Rupture of the Spleen occurs as a result of injury, causing great shock, pain in the left hypochondrium, and internal hæmorrhage, usually to such an extent as to prove rapidly fatal. In less severe cases the blood collects in the left loin, and gravitates towards the pelvis, the right loin being often kept clear by the position of the mesentery. Laparotomy should be undertaken whenever practicable, and, if much damaged, the organ is removed, the splenic vessels being secured by ligature; the results of such treatment have been most satisfactory. In a few cases it has been possible to stop the bleeding by suturing the spleen, or by inserting a gauze tampon, which is removed in a few days.

Abscess of the Spleen may develop in the course of pyæmia, or follow an injury, especially if associated with a lesion of a neighbouring coil of intestine. The symptoms are merely those of deep suppuration in the left hypochondrium, and the abscess either finds its way externally, or bursts into the peritoneal cavity. It may be opened and drained with the same precautions as for any other intraperitoneal collection of matter, and the results hitherto obtained have been encouraging. In pyæmia the disease is often fatal before the local phenomena are recognised.

Floating Spleen is occasionally congenital, but more commonly acquired, in consequence of tight-lacing, injuries, or the presence of tumours. It is characterized by the existence of a moveable intra-abdominal swelling, whose shape is that of the spleen, and having a notch in its anterior border; its size increases after meals. It may be so displaced as to lie in the right iliac fossa, or even in the pelvis, and then has a long narrow pedicle which has, in a few cases, led to its torsion and strangulation. Splenectomy was formerly the only treatment, if the displaced organ caused discomfort or pain; it has been found possible, however, to fix it, and several successful cases have now been recorded. *Splenopexy*, as the operation is termed, is best undertaken by preparing a bed for the organ outside the peritoneum in the loose cellular tissue beneath the floating ribs on the left side. The spleen is then slipped through a small hole specially made for the purpose in the parietal peritoneum, and secured by stitches, which pass through its capsule and anchor it to the under surface of the diaphragm.

Enlargement of the Spleen is not uncommon, and is due to many different causes. It is characterized by a swelling which extends downwards from the left hypochondrium towards the umbilicus, the notch, perhaps, being felt in front; it hugs the anterior abdominal wall, so that intestine is not found in front of it, whilst a resonant note is obtained in the flank. It is usually moveable with respiration, and occasionally increases in size after meals.

The commonest *causes* of this condition are as follows: 1. Certain general diseases, such as malaria, inherited syphilis, rickets, lardaceous disease, lymphadenoma, or generalized tuberculosis. 2. Passive hyperæmia, as the result of back-pressure from the heart, lungs, or liver; thus it occurs in chronic valvular disease of the heart, chronic pulmonary disease, and cirrhosis of the liver. 3. It is also met with in certain blood conditions, such as spleno-medullary leukæmia (for blood-count, see p. 67); splenic anæmia, in which the splenic enlargement is associated with a chlorotic type of anæmia, and is followed by cirrhosis of the liver, leucocytosis being noticeably absent, the syndrome constituting what is known as Banti's disease; and polycythæmia, in which there is an increase of the erythrocytes and an augmented hæmoglobin content accompanying the enlargement of the spleen. 4. A simple splenomegaly or hypertrophy of the spleen exists, in which the swelling is accompanied by no characteristic blood changes. 5. Tumours and cysts of the spleen also lead to its enlargement : the former are usually secondary and malignant in nature; the latter may be due to hydatid disease, or be of the nature of a simple serous cyst.

The differential *diagnosis* of these conditions cannot be discussed here, but it must suffice to point out that the chief reliance must be placed on a careful and thorough examination of the blood, together with a complete investigation of the condition of the other organs of the body.

Treatment necessarily varies with the cause, but if medicine is of no avail, the question of **splenectomy** will have to be considered. This operation has been performed for many different affections, and its value and position as a surgical procedure are now fairly well established. For traumatic lesions it is both safe and justifiable. For splenomegaly and for malarial enlargement it may be performed, if serious discomfort is being caused and cannot be otherwise remedied. If drainage fails to cure a cyst, or if a primary growth is discovered in a sufficiently early stage, excision may be undertaken. Splenectomy for leucocythæmia is absolutely unjustifiable, all the cases operated on having died. In splenic anæmia excellent results have followed removal of the organ in the few cases in which it has been attempted; the red cells subsequently increased rapidly in numbers, as also their hæmoglobin content, whilst the leucocyte count remained much the same. Such a result indicates that possibly the condition is due to an increased destruction of erythrocytes in the spleen, which is brought to an end by removing the organ.

The operation itself is performed through any suitable incision of sufficient length; probably one in the linea semilunaris is the best. The peritoneum having been opened, the organ is carefully examined to ascertain in particular whether or not adhesions are present, as, if extensive, any attempt to break them down might result in fatal hæmorrhage. If the organ is freely mobile, it is carefully drawn out of the abdomen, and the anterior layer of the gastro-splenic omentum divided so as to expose the vessels. Care is taken not to secure the main trunk at a distance, but the smaller branches as they enter the hilum. The lieno-renal and lieno-phrenic ligaments are divided, and the organ thus set free is removed. Gastric hæmorrhage has been known to occur after this operation, but is probably due to absence of care in securing the vessels close to the hilum, as if the splenic vein is tied so as to include the veins returning from the cardiac end of the stomach (vasa brevia) congestion of this part of the gastric wall will result, and may cause hæmorrhage.

CHAPTER XXXVI.

HERNIA.

By the term **Hernia** is meant the protrusion of some viscus from its normal situation through an opening in the walls of the cavity within which it is contained. This may affect not only the abdominal viscera, but also the brain and lungs, giving rise to conditions which have been already described. The present chapter is limited to hernia as met with in connection with the abdomen.

The most common **Situations** at which hernia occurs are those spots where the parietes are weakened by the transmission of such structures as the spermatic cord and round ligament (inguinal hernia), or at the entrance of the crural canal, where the main vessels of the leg pass under Poupart's ligament (femoral hernia), or at the umbilicus (umbilical hernia). Hernial protrusions may, however, develop through the obturator foramen, sciatic notch, the diaphragm, and in various other situations.

Ætiology.—A great many conditions may be associated, directly or indirectly, with the production of a hernia. They may, however, be described for practical purposes under two main headings—the congenital and the acquired.

Congenital Causes are rather predisposing than exciting in nature, and must be looked for amongst the many malformations and conditions of imperfect development to which the abdominal parietes and contents are liable. The following are the most important of these: (*a*) The non-obliteration of the funicular process of peritoneum, which in the male precedes and accompanies the testicle on its progress downwards from the abdominal cavity to the scrotum, and in the female passes along the round ligament. The so-called congenital inguinal hernia results from this, although it must be remembered that the rupture does not necessarily show itself at birth, and, indeed, may not appear till after puberty. It is probable that incomplete obliteration of this process is the cause of a great majority of the cases of oblique inguinal hernia, a small pouch being left at the upper end. It is often possible to demonstrate the existence of this in patients with weak, bulging groins, but with no actual hernia. In females under the age of twenty-five, hernia into the canal of Nuck, as this peritoneal tube is called, is the most frequent variety met with.

(*b*) The late descent of the testis, whether it finds its way into the scrotum or not, is usually associated with the formation of an inguinal hernia of the congenital type, or of some form of interstitial hernia. (*c*) Inherited weakness of the abdominal muscles and parietes, with unusual patency of the rings, will certainly predispose to this condition, and, moreover, there is no doubt as to the tendency of hernia to run in families. (*d*) Abnormal length of the mesentery or omentum has also been looked on as a causative factor; but, although it may have some influence when other conditions are present, it can *per se* have but little effect. (*e*) Congenital phimosis, by inducing forcible acts of micturition, acts as an exciting cause. (*f*) Congenital apertures occur in the linea alba or linea semilunaris, especially opposite one of the tendinous intersections in the rectus, and through these one form of ventral hernia may develop. (*g*) The umbilicus is sometimes imperfectly developed at birth, permitting the viscera to protrude into the base of the umbilical cord (congenital umbilical hernia). (*h*) The diaphragm is also occasionally defective, allowing the stomach or other viscera to find their way into the thoracic cavity.

Acquired Causes.—Hernia may result from any condition which tends either to weaken the abdominal parietes, or to increase the intra-abdominal pressure. Thus (1) it may be *post-operative*, resulting from the imperfect development of a cicatrix after a laparotomy. (2) It may be the outcome of *direct traumatism*, and is then just as likely to occur away from the hernial regions. If seen early, the affected area will probably show signs of injury, such as tenderness, swelling, and ecchymosis, but a hernia is by no means a necessary consequence. It is unusual for an ordinary complete hernia to develop after injury or severe strain, unless a pre-formed sac is present, and then immediate strangulation is not an uncommon sequence; apart from this, the hernia, if seen soon after the alleged accident, is imperfectly developed, and in the bubonocele stage. The fact that compensation may be required for the development of a hernia should make practitioners cautious in giving opinions as to ætiology. (3) Much more frequently hernia is due to *chronic strain*, such as occupations which involve lifting heavy weights, and the more so if the individual is forced to maintain the upright position, or wears tight bands or girths round the abdomen. Prolonged and severe bronchitis, and frequent straining to pass water in cases of enlarged prostate or stricture, may determine the development of a hernia; whilst chronic constipation is a frequent factor in its production, especially if the patient makes use of a closet with a high seat, whereby the inguinal canals are left unprotected; a patient with weak and bulging inguinal regions may with advantage use a low commode. (4) *Relaxation of the abdominal parietes* also favours hernia, especially if associated with or followed by severe straining. Thus pregnancy brings about a stretching of the wall, especially if frequently repeated and followed by imperfect involution; and parturition determines the development of hernia, either in the crural region or through the linea alba. Similarly the relaxed and atonic abdominal wall, which bulges down in the hypogastric region in old people, favours the occurrence of a direct inguinal hernia, should the patient have a bad cough or an enlarged prostate. In old and weakly people an additional cause may be found in the slipping downwards of the mesenteric attachment, causing the intestines to occupy the lower part of the abdomen rather than the upper, so that the former bulges out over the pelvic brim. This is possibly due to weakening or relaxation of the unstriped muscular tissue which normally exists behind the peritoneum, passing from the posterior abdominal wall to the base of the mesentery; it is sometimes called the *muscle of Treitz*. (5) *Obesity* is also a predisposing factor to hernia, the accumulated fat being deposited in the omentum, mesentery, and subperitoneal tissue, thus increasing the intra-abdominal tension.

Structure.—A hernia consists of a sac and its contents, the sac being formed of peritoneum, perhaps thickened by additional coverings, derived from the abdominal parietes, and the contents being the protruded viscera.

The *sac*, or peritoneal investment of an acquired hernia, is in the early stages funnel-shaped, small, and thin, being derived from that portion of the serous membrane which normally lies over the hernial aperture. As the rupture increases in size, the sac becomes larger, partly by stretching, and partly by the drawing down of fresh membrane from the neighbourhood. Occasionally it stretches irregularly and becomes sacculated, and sometimes the sac becomes hour-glass-shaped, probably as the result of inflammation. The sac is described as consisting of two portions—the neck and the fundus. The *neck*, sometimes large and open at first, gradually becomes narrowed, and is generally thickened from the irritation to which it has been exposed, either from the wearing of a truss or from the pressure of the contained viscera. The body, or *fundus*, varies much in size and shape, and may undergo considerable alterations in structure.

(*a*) The sac soon becomes *adherent* to surrounding parts; and with increasing irritation, as by a truss, these adhesions become more definite. (*b*) *Inflammation* may occur as the result of injury or pressure, constituting a form of localized peritonitis. If this is of a chronic type, the sac becomes thickened and opaque, with dilated vessels coursing over it, as seen especially in old irreducible herniæ. Acute or subacute inflammation is also met with, resulting in the formation of adhesions between the inner wall and the contained viscera, or between the opposite sides of the sac, if no other structures interpose. Natural cure of a hernia may occasionally be produced in this way by adhesions forming across the neck of the sac, or by an adherent plug of omentum, thus occluding the communication with the peritoneal cavity. The lower portion of the sac may in a similar way be shut off from the upper, either by a band of adhesions or by a septum of adherent omentum; this isolated cavity is sometimes the seat of a serous effusion, known as a *hydrocele of a* *hernial sac.* (*c*) Hæmorrhage into the sac wall may result from violence, and will cause it to become much thickened, and even pigmented or leathery in appearance.

The *coverings* of the sac are indurated in old-standing cases, and matted together in such a manner as to make it difficult to recognise the constituent parts. This is specially noticeable at the neck of the sac, where their union with surrounding structures is often such as to constitute an important predisposing element in the production of strangulation. The opening through which the hernia protrudes loses its characteristic features and shape, being enlarged, more or less circular, and displaced, so that an oblique passage, such as the inguinal canal, becomes straight, the internal abdominal ring lying almost immediately behind the external.

Contents.—Any viscus in the abdomen may be found in the sac of a hernia, except, perhaps, the pancreas; as a rule, however, one finds only small intestine or omentum.

An *enterocele* is the name given to a hernia containing some portion of the bowel. It is at first reducible; but if the gut becomes adherent, either to the sac or to some other contained structure, it is rendered irreducible. It may also participate in an inflammatory condition of the sac; whilst, if irreducible, obstruction may ensue from impaction of its contents, and if its vessels are constricted strangulation supervenes. For a description of these conditions, see p. 1110. The small intestine is much more frequently involved than the large gut. The amount of bowel protruded varies from a few inches to several feet.

If omentum is found in a hernial sac, the condition is known as an *epiplocele.* As long as it remains reducible, it is likely to retain its normal texture; but when large in amount, and especially if irreducible, it becomes thickened, brawny, and matted together to such an extent as almost to constitute a solid tumour; it is often the seat of an excessive deposit of fat, and in consequence of this overgrowth it may become irreducible, even when no adhesions are present. Serous cysts sometimes develop within it as a result of effusion between opposed surfaces. In some cases openings are found in it of sufficient size to allow the gut to pass through and become strangulated. When omentum and bowel are present in the same sac, the condition is known as an *entero-epiplocele.*

The *Cæcum* sometimes occupies a hernial sac, either in aggravated and large herniæ, or in children with congenital hernia; it has even been found in a hernia on the left side. Since the cæcum has generally a complete serous covering and usually a mesentery, it is freely moveable, and may pass into a hernial sac in the same way as any other moveable part of the intestine. On the other hand, a few indisputable cases have been related in which the serous envelope was incomplete in a so-called ‘ cæcocele.’

The *Vermiform Appendix* is occasionally found in a hernial sac on the right side. It is rarely free, but generally fixed by adhesions and irreducible. The hernia is more painful than usual, and on palpation the appendix can sometimes be felt enlarged and tender, pressure causing pain referred to the umbilicus. The patient is likely to give a history of recurrent attacks of inflammation in the sac.

The *Bladder* may be associated with a hernial sac in two distinct ways, and usually in the inguinal region. (*a*) The fundus may be dragged downwards by the traction of the peritoneum, when the hernia has attained a colossal size. There is then only a partial peritoneal investment, the bladder lying outside the sac, and being adherent to it. Considerable irritability of the viscus is induced, and, owing to stagnation of urine in the displaced part, a phosphatic concretion may form therein, and such has even been removed by incision through the scrotum. (*b*) Occasionally a saccule of the outer wall of the bladder becomes adherent to the peritoneum, and is drawn down by it into the inguinal canal; its presence may be suspected if a small hernia is associated with much vesical irritability. The saccule consists merely of thickened mucous membrane and submucous tissue, and is devoid of muscular fibres; it is very liable to be laid open when an operation for the radical cure is undertaken. If such an accident happens, the saccule should be excised, and the opening at once closed by sutures, which should not penetrate the mucous membrane. Failure to recognise this accident is followed by urinary extravasation, possibly intraperitoneal, and will require prompt treatment if a fatal issue is to be avoided. The wound must be re-opened, the gap in the bladder wall found and closed, and effective drainage provided.

The *Ovary* and *Fallopian Tube* are occasionally found in an inguinal hernia, more often in a child than in an adult, and give rise to an irreducible swelling, pressure on which causes a sickening pain.

Loose foreign bodies, somewhat resembling marbles in size, are occasionally, but very rarely, met with in hernial sacs. They are derived from the detachment of one or more of the appendices epiploicæ, which subsequently become enlarged from a deposit of fibrin induced by movement in the peritoneal cavity, and may even calcify.

Signs and Symptoms.—The characteristic features whereby a hernial protrusion is recognised consist in the presence of a rounded or pyriform swelling, in one of the normal or abnormal situations already mentioned, which increases in size when the patient stands, coughs, or strains, having, as it is termed, ‘an impulse on coughing.’ If intestine is present, it may be possible to obtain a tympanitic note on percussion, whilst the tumour is tense and rounded, and on pressure slips back into the abdomen with a distinct gurgle. An enterocele often gives rise to dyspeptic phenomena, and perhaps to colicky pains. An omental hernia feels soft and doughy, has a less distinct impulse, or even none, on coughing, and is replaced without a gurgle; it is dull on percussion. When allowed to reappear, it does so slowly without any sudden impulse, the omentum insinuating itself gently down the inguinal canal, and gradually distending the sac.

The **Treatment** of hernia, whether palliative by means of trusses, or radical by means of operation, differs so greatly in the various forms, that it will be better to discuss each one separately.

Special Forms of Hernia.

Inguinal Hernia.—The term **inguinal hernia** is limited to those conditions in which a protrusion occurs into the inguinal canal, and, if allowed to progress, finally makes its way through the external abdominal ring. If it extends into the scrotum, it is termed *complete*, or scrotal; whilst if it does not pass beyond the external abdominal ring, it is known as a *bubonocele*, or incomplete inguinal hernia. The neck is always in relation with the deep epigastric artery, and the structures of the cord are either spread out over the sac or are in close proximity to it. In the early stages, the pubic spine can be felt to the outer side of the neck of the sac; but as it increases in size, it lies over the spine, which can only be felt after pushing the hernia upwards and inwards.

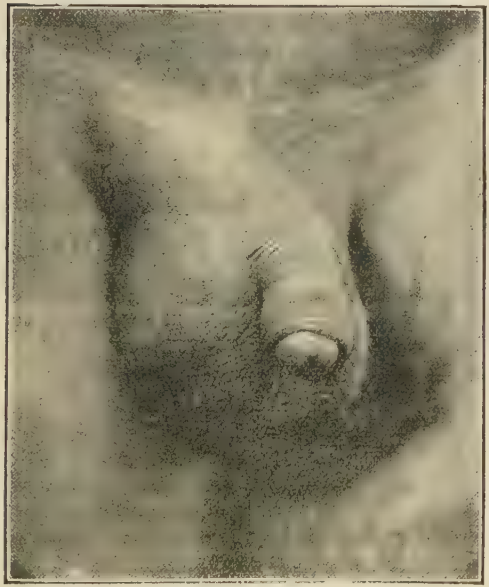

FIG. 505.—OBLIQUE INGUINAL HERNIA.

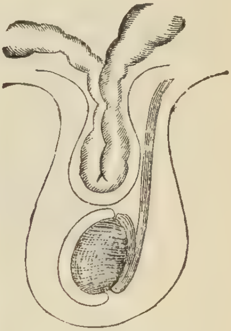

FIG. 506.—DIAGRAM OF ACQUIRED INGUINAL HERNIA, SHOWING SEROUS SAC WITH INTESTINE COMING DOWN TO THE TOP OF THE TESTIS.

Two main **varieties** of inguinal hernia are described, viz., the oblique and the direct.

An **Oblique Inguinal Hernia** (Fig. 505) is one which passes down the whole length of the inguinal canal, entering at the internal and emerging at the external abdominal ring; the deep epigastric artery is thus placed to the inner side of the neck. During its passage through the canal every form of oblique hernia pushes before it and becomes covered by structures representing the various layers of the abdominal parietes. Hence in cutting down on such a sac, the surgeon will divide, in addition to the skin and subcutaneous tissues (*a*) the intercolumnar fascia, derived from the transverse fibres of the external oblique which pass across the external abdominal ring;

(*b*) the cremasteric muscle and fascia, representing and extending from the internal oblique; (*c*) the infundibuliform fascia derived from the fascia transversalis; and (*d*) finally, a layer of subserous tissue varying in thickness, and closely surrounding the peritoneal sac. Probably the surgeon will only recognise the muscular fibres of the cremaster, which serve as a useful landmark.

There are three different forms of oblique inguinal hernia, viz., the acquired, the congenital, and the infantile or encysted.

1. An *Acquired Inguinal Hernia* (Fig. 506) is one in which the sac consists entirely of peritoneum protruded from within the abdomen. It gradually increases in size, and finds its way along the cord to the scrotum. The sac usually extends as far as the head of the epididymis, but if of a large size it may overlap the testicle, which lies behind it. The structures of the cord are frequently spread out over the sac. In old-standing cases the internal ring is dragged downwards and inwards, and often lies behind the outer, and thus it may be difficult, apart from operation, to determine whether any particular hernia is direct or oblique. Even in early cases the sac is distinctly flask-shaped, suggesting that the condition is due to the non-closure of the uppermost part of the funicular process.

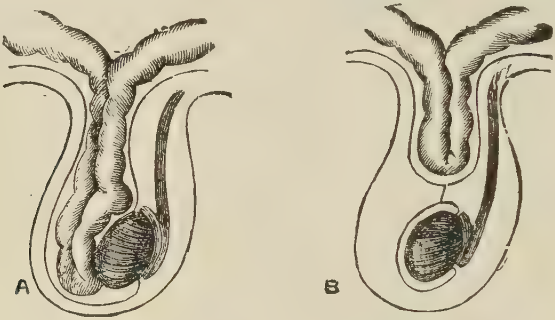

FIG. 507.—CONGENITAL INGUINAL HERNIA.
A, Vaginal variety; B, funicular type.

2. *Congenital Inguinal Hernia* (Fig. 507) is due to non-closure of the funicular process of peritoneum, which passes down to the scrotum with the testicle, and is usually obliterated completely except below, where it forms the tunica vaginalis. As already mentioned, the hernia does not necessarily appear in infancy, its occurrence being often delayed until puberty, or when the patient has to undertake heavy work. This form of hernia is much more frequently met with on the right side of the body, owing to the fact that the right testicle descends into the scrotum at a later date than the left. It is always characterized by becoming complete at once, and its development may be immediately followed by acute strangulation.

When the non-obliteration is complete and the patent funicular process is continuous with the tunica vaginalis, the protruded viscera lie in contact with the testis, and somewhat obscure it; this is known as a *congenital vaginal hernia* (Fig. 507, A). Less frequently the funicular process is patent only as far as the head of the epididymis, being shut off from the tunica vaginalis. The hernia under such circumstances exactly resembles the acquired variety, being unrecognisable from it except by the fact that it becomes complete at once. It is termed a *congenital funicular hernia* (Fig. 507, B).

In congenital hernia the structures of the cord are usually more intimately adherent to it than in the acquired form. Phimosis is often associated with this condition in young boys.

3. The *Infantile* or *Encysted Hernia* is one occurring in individuals in whom the funicular process, although shut off from the abdominal cavity above, remains patent below, communicating with the tunica vaginalis, which cavity extends, in consequence, as high as the inguinal canal (Fig. 508, A). The hernia has a distinct sac, which passes down behind the open process, or invaginates it (Fig. 508, B and C). It cannot be recognised except on operation, when the surgeon is apt to open the tunica vaginalis, which, though reaching upwards, does not communicate with the general peritoneal cavity; on removing or displacing this, the true sac of the hernia is found behind it. This does not often occur at the present day, when the high incision is made.

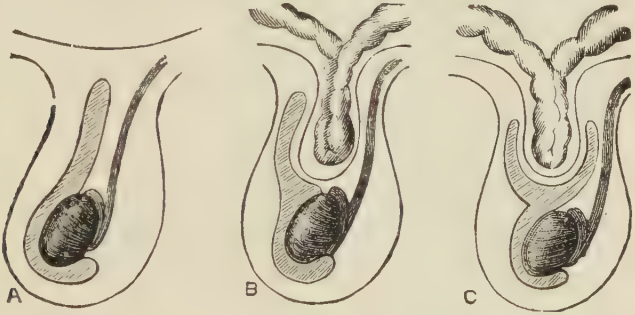

FIG. 508.—INFANTILE INGUINAL HERNIA.

A, Prehernial condition with tunica vaginalis extending upwards to inguinal canal; B, hernial sac coming down behind tunica; C, sac invaginating the tunica vaginalis.

A **Direct Inguinal Hernia** (Fig. 509) is one which, though passing through the external abdominal ring, has only travelled through a portion of the inguinal canal; it is never congenital, and usually smaller than the oblique type, not becoming scrotal. The neck lies to the inner side of the epigastric artery, which is often arched very distinctly over it, passing also along its upper wall. The hernia thus escapes through the lowest portion of the linea semilunaris, and traverses the space known as Hesselbach's triangle, which is bounded internally by the outer border of the rectus muscle, by the deep epigastric artery externally, and by Poupart's ligament below (Fig. 510). The obliterated hypogastric artery passes across the space in a direction parallel to its outer border, dividing it into two parts, and according to whether the hernia protrudes through the outer or inner segment, it is known as an external or internal direct hernia (Fig. 510, 2 and 3). The spermatic cord usually lies to the outer side of a direct hernia, and its constituent elements are never spread out over the sac as in the oblique form. A direct hernia is rarely found in young people, and there is often a considerable amount of subperitoneal fatty tissue around the sac. The coverings are practically the same as in the oblique variety, although the cremasteric investment may be less complete.

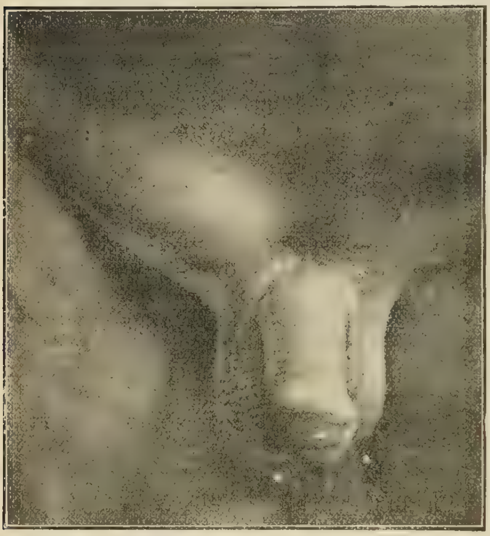

FIG. 509.—DIRECT INGUINAL HERNIA.

Interstitial Hernia is the name given to an inguinal hernia which develops in some abnormal relation to the abdominal wall. Three varieties are described: (*a*) Where a sac exists between the transversalis fascia and the peritoneum (*intraparietal* form, or *properitoneal* hernia), either with or without a hernia in the usual position; in the former instance one form of 'hernia en bissac' is produced. This abnormal pocket of the sac is found either between the symphysis pubis and the bladder (hernia inguinalis ante-vesicalis), or it extends outwards towards the iliac fossa (hernia inguinalis intra-iliaca). As no external swelling is caused by this condition, it is usually impossible to recognise its existence prior to operation; occasionally it is the cause of a continuation of the symptoms of strangulation, when apparently successful taxis has been performed, owing to the strangled bowel having been pushed backwards from the superficial into the deeper portion of the sac. (*b*) An abnormal expansion of the sac is situated between the internal and external oblique muscles (*interparietal* form). A swelling is thus produced in the region of the inguinal canal, covered by the external oblique aponeurosis, and gradually spreading upwards and outwards parallel with Poupart's ligament. It may be associated with late descent of the testis, the external abdominal ring being closed so that the organ, and with it a hernia, has to travel beneath the external oblique aponeurosis. Sometimes the condition is due to the existence of a more or less complete septum at the level of the external abdominal ring, formed either by adhesions or by a mass of adherent omentum. The sac is then shaped like an hour-glass, and as the usual downward course of the hernial contents is prevented, the upper part of the sac yields laterally above the site of the obstruction, and passes between the muscles. (*c*) The hernia escapes as usual from the external abdominal ring, but travels outwards along Poupart's ligament, somewhat simulating a femoral hernia (*extra-parietal* variety). This form is generally associated with late descent of the testis, and a contracted state of the scrotum, so that it is easier for the hernia, which is always of a congenital type, to pass into the thigh, and be guided by the fascia in the direction indicated; in a case of this character operated upon some years back, the testicle was found lying close to the anterior superior iliac spine. There is no difficulty in recognising such a condition.

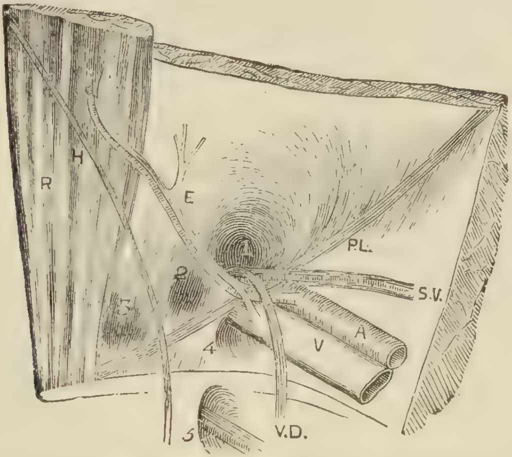

Fig. 510.—Abdominal Wall from Within, to show Hernial Apertures.

A, V, External iliac artery and vein; SV, spermatic vessels; PL, Poupart's ligament; VD, vas deferens; E, epigastric vessels; R, rectus abdominis; H, obliterated hypogastric artery; 1, internal abdominal ring; 2 and 3, sites of direct hernia in Hesselbach's triangle; 4, crural ring for femoral hernia; 5, obturator foramen and vessels.

The **Signs** of an inguinal hernia do not require much special notice here, as we have already described the general clinical features of a rupture (p. 1088). In the early stages, where merely a bubonocele exists, a fulness is noted in the course of the inguinal canal, which increases when the patient coughs; it is best detected by a finger passed through the external ring into the canal. When it descends into the scrotum, the swelling increases in size from above downwards, and in the oblique variety is continuous with the fulness in the inguinal canal. The structures of the cord are masked by the presence of the hernia, but the testicle is to be felt more or less distinctly at the lower and back part of the swelling. When of the direct variety, the cord lies to the outer side, and although the hernia can be felt projecting from the external ring, it passes directly backwards, and there is no fulness along the course of the canal.

Inguinal hernia is usually met with in the male sex, the oblique variety being more common in the young, and the direct in elderly patients. In the female sex it is not unfrequent, however, in girls and young nulliparous women; in such cases it is almost always congenital, passing into the labium along the canal of Nuck, but rarely attains any considerable size.

The **Diagnosis** of an inguinal hernia is a tolerably simple matter if it is uncomplicated by any other condition; it may, however, be difficult, and in old-standing cases it is often impossible to distinguish the oblique variety from the direct. The conditions for which it may be mistaken are best considered in two groups.

1. Whilst the hernia is still incomplete and in the bubonocele stage, it has to be distinguished from the following: (*a*) *Encysted hydrocele* of the cord, which is recognised by its smooth globular outline and tense walls; the impulse on coughing is less distinct, and, although freely moveable in the canal, the hydrocele cannot always be entirely reduced into the abdomen, whilst the characteristic gurgle of a hernia is absent; traction on the testis, moreover, fixes the tumour, and renders it immobile. The exact limitation of the upper end of the swelling, if it can be reached, is very characteristic of a hydrocele. (*b*) A *chronic abscess* originating in the abdominal parietes, or within the abdomen or pelvis, will sometimes point through the external abdominal ring. In such cases, although there is a distinct impulse on coughing, and although the swelling is reducible, it has not the definite outline and characteristic sensation of a hernia, being usually soft and fluctuant. Other evidences pointing to the existence of the original disease may also assist in determining the nature of the swelling. (*c*) *Enlarged glands in the groin* which have become adherent to the external oblique are sometimes mistaken for a hernia, owing to the fact that on coughing a distinct impulse is communicated to them; it is, however, merely heaving in nature, and not expansile, whilst on digital exploration of the inguinal canal the absence of a hernia may be readily ascertained. (*d*) A *testicle retained in the inguinal canal* is recognised by that side of the scrotum being empty, and on pressing the swelling testicular sensation may be elicited. The rounded upper end of the testis can often be detected. (*e*) *Tumours consisting of fat or other tissues* are occasionally seen in the inguinal canal, but are characterized by the strict limitation of their upper border, and usually by the absence of a distinct impulse on coughing. On the other hand, as described elsewhere, a mass of fat simulating a lipoma is often present, resulting from a protrusion of the subperitoneal tissue, a hernial sac being sometimes found

embedded within it. (*f*) *Hæmatocele of the cord* is recognised by a history of injury, the presence of pain and ecchymosis, and the absence of an impulse on coughing, whilst reduction is impracticable.

2. *When the hernia extends into the scrotum*, less difficulty is experienced in its diagnosis. By examination of the cord immediately outside the external abdominal ring, all purely scrotal swellings, such as hydrocele or sarcocele, are readily eliminated, since in them the cord can, in the early stages, be felt perfectly free. A varicocele can also be similarly recognised from an omental hernia by the condition of the cord in its upper region; moreover, if the patient is made to assume the recumbent posture, the swelling disappears in each instance, but if a finger is placed firmly over the inguinal canal so as to prevent any protrusion of omentum, and he is then directed to stand up, the swelling immediately reappears if it is venous in character. To the practised hand, the diagnosis is never a matter of difficulty, since the enlarged veins of a varicocele and omentum are not at all alike to the touch, the veins moving freely under the finger 'like worms in a bag.' When a hernia is associated with a hydrocele or sarcocele, a little more care is necessary in order to distinguish between the two swellings.

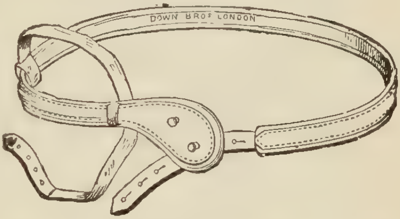

FIG. 511.—INGUINAL TRUSS. (DOWN BROTHERS.)

The **Treatment** of inguinal hernia is either palliative by means of trusses, or radical.

Palliative Treatment. — A truss is an appliance which is worn around the body with the object of preventing by pressure the descent of the hernia. No one form is capable of dealing with every case, and hence the truss must be selected with care, so as to suit the special needs of the particular patient. A good truss consists of a pad kept in position over the hernial aperture by a steel spring (Fig. 511), which fits the patient accurately, resting behind on the middle piece of the sacrum, and passing laterally midway between the crest of the ilium and the top of the great trochanter. If the hernia is unilateral, the spring ends on the sound side just behind the anterior superior spine, and is prolonged anteriorly into a leather thong or cross-strap, which is secured to a stud on the pad. To prevent it from slipping up, an under-strap passes from the affected side close behind the anterior superior spine along the fold of the nates to the inner side of the thigh, being fixed finally to a second stud on the pad. The pad may be rounded or oval in shape, and usually consists of soft iron protected by cork, but polished vulcanite, wood, or an indiarubber cushion filled with air, water, or glycerine, may be employed instead; it should be well covered with leather, and the strength of the spring must be so adjusted as to retain the hernia under all conditions of strain to which it may be subjected, but without the use of undue force. In ordering a truss from an instrument-maker, the only measurement required is that around the body, following the line taken by the truss, and reaching in front to the symphysis pubis; it is also advisable to indicate the size of the hernia, and whether the opening in the abdominal parietes is large or small. In the earlier cases of oblique hernia, the pad should rest rather over the inguinal canal than over the external abdominal ring, the object being to restore the valve-like action of the canal by approximating its sides. In a direct hernia the pad must be applied directly over the opening. If such an apparatus is properly adjusted and continuously worn, a cure is sometimes established in the course of a year or two; and in the congenital hernia of children a cure may be confidently expected if the mother or attendants of the child conscientiously carry out the necessary details. If the hernia is once allowed to slip down, even after six or twelve months' treatment, all the previous good will have been undone.

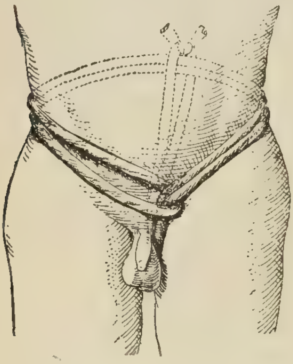

FIG. 512.—WOOL TRUSS FOR TREATMENT OF LEFT INGUINAL HERNIA IN AN INFANT.

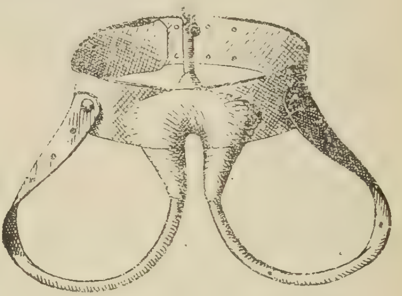

FIG. 513.—INDIARUBBER BAND TRUSS, WITH AIR-PADS, FOR INFANTS.

The air-pads fit around the root of the penis, and are inflated through the tube tied up in front. The under-straps fit round the child's thighs.

In infants, an efficient support is afforded by a skein of wool (specially known as 'fingering'), divided at one end, so that when placed round the body the cut ends of the skein can be passed through the loop, forming a knot over the inguinal canal, which acts as the pad of a truss. The cut ends are now passed under the perineum, and tied to the transverse portion behind (Fig. 512). This apparatus is changed night and morning when the child is bathed, and also, if need be, at shorter intervals, the mother being previously instructed as to how to support the hernia whilst the apparatus is being removed. In cases of double rupture in infants, an indiarubber band with two pneumatic air-pads (Fig. 513), arranged so as to fit over the inguinal canals, and with suitable straps and studs, will often suffice, and is certainly more comfortable than a spring truss. In addition to such pressure, it is important to remove all causes of intra-abdominal tension, as by circumcision, where phimosis is present, or by regulating the bowels.

The **Radical Cure** of inguinal hernia is an operation to which much attention has been directed of late years, since its value was brought prominently before the profession by the late Professor John Wood and others. It is very largely employed at the present day, and may be expected to give excellent results if the cases are carefully selected, if the technique is satisfactory, and if the after-treatment is efficient. The mortality is very small, and in a series of 7,419 cases collected by Sultan, it did not exceed 0·48 per cent.*

The selection of cases for an operation of this type, which is not an essential, but only a desirable means of treatment (or, as it is sometimes termed, an *opération de complaisance*), is a matter requiring considerable judgement and discrimination. In an individual whose occupation does not subject him to heavy strain or exertion, and who possesses a hernia which, under ordinary circumstances, is easily commanded by a suitably applied truss, no operation is absolutely necessary; although one is perfectly justified in urging him to submit to it, since he will be thereby freed from the irksomeness of wearing a truss, and from the possible occurrence of strangulation. If, however, the subject is a labouring man, exposed to injury and strain, and who may find it difficult to provide a suitable series of trusses, the operation should always be undertaken unless distinctly contraindicated (1) by a general inherited weakness of the abdominal muscles; (2) by a relaxed and atonic condition of the abdominal parietes, which is commonly associated in elderly people with slipping downwards of the mesenteric attachment of the intestine (enteroptosis), so that the hypogastrium obviously bulges; or (3) by such constitutional disease as precludes all unnecessary operative interference. (4) Again, in cases of extensive irreducible hernia, the return of large masses of intestine which have lain for years in the hernial sac so increases the intra-abdominal tension as frequently to determine recurrence locally or elsewhere, and therefore operative interference, though very desirable owing to the great risk of strangulation incurred by the patient, is often followed by very bad results, unless the patient has previously been put through a course of semi-starvation and persistent taxis in order to reduce gradually the size of the protrusion.

As to the best age at which to operate, statistics definitely prove that it is essentially an operation of adolescence, the results gradually getting worse as the age increases. Young children should not be touched until careful truss pressure for a year has failed, or unless it is impossible to keep up the hernia by such treatment. In any case it is perhaps wiser to delay it until the age of three, or even later, owing to the risk of infection of the wound from the constant saturation of the dressings with urine.

Very many different operations have been described and practised by various surgeons. One of the most satisfactory is that known as

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* *Münch. Med. Wochens.*, February 3, 1903.

Bassini's, which has now been extensively employed, and has been followed by a large measure of success. The operation may be described in the following stages: (1) The pubic region having been previously shaved and thoroughly purified, an incision is made in the direction of the inguinal canal and cord, about 2½ inches in length, its centre being a little above the external abdominal ring. This is carried through the skin and subcutaneous tissues until the structures of the cord are reached, the superficial external pudic artery being necessarily divided *en route*; the pillars of the ring are clearly defined, and the external oblique aponeurosis slit up in the direction of the cord. (2) The sac has now to be identified; if the hernia is one of old standing, or contains adherent omentum or intestine, it is easily recognised; but if it is thin, empty, and of recent formation, and especially in the case of a bubonocele, its identification may be a matter of some difficulty. The cremaster and other coverings of the cord are incised longitudinally, and the sac looked for and isolated with as little handling and disturbance of the parts as possible. Enlarged veins may be removed, as also fatty protrusions from the subperitoneal tissues. It is sometimes necessary to lift up the structures of the cord in order to define the sac, which is often recognised by the white convex border of the fundus. (3) If the sac is empty, it is freed from its connection with the structures of the cord without opening it, and isolated as far as or beyond the internal abdominal ring, as indicated by a collar of fatty subperitoneal tissue surrounding the neck. If the hernia is irreducible, the sac is laid open, its contents freed from adhesions, and the intestine returned into the abdomen, whilst omental tissue is removed and the stump replaced. Adhesions are carefully divided either by the finger or between ligatures; if the gut is closely adherent to the sac, it may be necessary to leave a small portion of this attached to the intestine, which is then returned. Omentum, whether adherent or not, should be removed, as the elongated fringes are very liable to contract adhesions to the abdominal parietes, which subsequently produce mischief. In removing omentum, it is not advisable to encircle a large mass with a single ligature, as it is then more difficult to replace, the vessels are less securely commanded, and a pocket or pucker may be produced, possibly leading to internal strangulation at a later date. Small portions, including one or more of the larger vessels, should be taken up one after another, and tied separately and with advantage at different levels, so as to assist in the subsequent return of the stump. The protruded mass is then cut away below the ligatures, and the stump replaced after seeing that no bleeding-point remains unsecured. The sac, being now emptied, is isolated as far as the internal ring. (4) The neck is transfixed as high as possible, and ligatured with sterilized silk, and the sac cut off below the ligature, the stump retracting well above the internal ring, and presenting a flush surface towards the intestines. (5) The opening in the abdominal parietes is closed by a row of sutures passing through the arched fibres of the internal oblique and transversalis muscles or through the conjoined tendon on the inner side, and through Poupart's ligament on the outer, the stitches being all placed *behind* the cord. To effect this, the cord is drawn up out of the wound and held aside by a retractor (Fig. 514, C), whilst the divided margins of the external oblique aponeurosis are grasped by pressure forceps (A, A′). Gentle traction on the lower pair enables the deepest portion of Poupart's ligament to be defined and seen. The stitches must secure a good hold of the tissues, but should not include the external oblique aponeurosis, and when dealing with Poupart's ligament the proximity of the iliac vessels must not be forgotten. Either interrupted or looped mattress sutures may be used, but if the latter, they must not be tied too tightly, as they may strangle the portions of tissue included in their grasp and cause necrosis. The opening in the abdominal parietes is in this way commanded as far down as the pubic spine, but sufficent room must be left at the upper end for the passage of the cord, undue constriction of which would cause atrophy of the testis; sometimes it is desirable to introduce a stitch above the cord, in order to command a spot where recurrence is not uncommon. When the three or four needful stitches have been introduced and tightened, the cord is replaced, and the divided portions of the external oblique are sutured

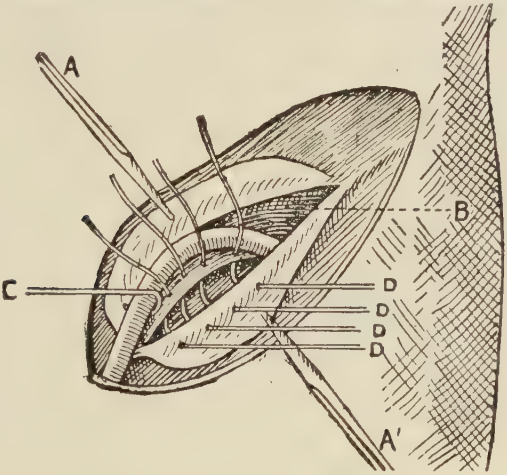

FIG. 514.—BASSINI'S OPERATION FOR RADICAL CURE OF HERNIA.

A, A′, Spencer Wells forceps, holding aside the divided portions of external oblique aponeurosis; B, arched fibres of internal oblique, continuous on the inner side with the conjoined tendon; C, hook or retractor holding aside the spermatic cord; D, D, D, D, deep silk stitches passed behind the cord through the deepest fibres of Poupart's ligament on the outer side, and conjoined tendon on the inner. (The cutaneous incision and the incision through the external oblique are here shown much greater than would actually be undertaken, in order to demonstrate clearly the deeper parts.)

together over it. (6) The wound in the skin is closed by a continuous suture, and usually no drainage-tube is needed.

After-Treatment.—The patient is placed in bed with the knees slightly flexed over a pillow. The wound, as a rule, does not require dressing for seven or eight days, when, on removal of the stitches, it should be found completely healed, if asepsis has been maintained. The patient should turn to the opposite side in order to pass water, and the greatest care must be taken to prevent the dressing becoming soiled. Occasionally retention of urine follows this operation, necessitating the use of a catheter. In the case of children, it is well to employ the open method of treatment suggested on p. 281.

The recumbent posture should be maintained for three weeks, and nothing but the slightest work undertaken for at least six weeks, and no violent effort until six months after the operation. Under such circumstances the use of a truss is unnecessary, and, indeed, undesirable, as its pressure is liable to produce atrophy of the newly-formed cicatricial tissue. When, however, the abdominal walls are congenitally weak, or if, unfortunately, the wound has suppurated, the deep stitches coming away, it is advisable to use a light truss for a time.

The treatment of *congenital hernia* differs in no particular from that already described, except that the sac must be divided below as well as above, and the lower opening secured by suture or ligature, so as to close the cavity of the tunica vaginalis. The operation often proves difficult owing to the intimate adhesions between the sac and the structures of the cord, and it is sometimes impracticable to isolate completely the neck of the sac.

The other operations which require to be mentioned are as follows:

(*a*) In *Banks' Operation*, the sac is isolated and removed as high as the internal ring without any division of the external oblique. Stitches are then introduced through the conjoined tendon and Poupart's ligament respectively, including the external oblique in their grasp, and passing *in front of* the cord. It is obvious that by such a plan the deep ring cannot be closed as accurately as in Bassini's operation. It may suffice, however, in a few of the simpler congenital cases.

(*b*) In *Macewen's Method* the aponeurosis of the external oblique is most carefully maintained intact, and the inguinal canal is explored through the external abdominal ring. The sac is freed from its surroundings, and this liberation goes on for about an inch all round the internal abdominal ring. A silk suture is then tied to the fundus of the sac, and is carried by a curved needle through the centre of the sac from above downwards, and again through the neck of the sac from below upwards. The needle is then introduced through the inguinal canal under the loosened abdominal parietes, and is made to emerge through the abdominal muscles a little above the inguinal canal; the silk thread is carried through this, and by a little traction the sac is carried in, doubled up, and implanted as a pad across the internal ring. This thread is held by an assistant during the next step of the operation. This consists in closing the canal by one or more looped sutures, passed in such a way as to draw up Poupart's ligament over the arched fibres of the internal oblique in front of the cord. Finally, the thread used for the fixation of the sac is drawn tight, and its free end employed to close the external abdominal ring to a sufficient extent. The results of this proceeding are very good but it is a more difficult operation than Bassini's, and one loses the advantage of opening the canal, and thereby exploring the structures of the cord. Subperitoneal lipomata are frequently found in the canal, and these would inevitably be left, and would possibly lead to a recurrence of the hernia, if the canal had not been opened up.

(*c*) In *Halstead's** operation the inguinal canal is opened up as in Bassini's method, and the cremaster divided longitudinally along the upper border of the cord, and dissected back, so as to enable the sac and any enlarged veins, etc., to be removed. The lower border of the internal oblique is defined, and the upper edge of the cremaster is sutured to the under surface by a series of mattress stitches. The lower edge of the internal oblique and conjoined tendon is then sutured in front of the cord to the under surface of Poupart's ligament, and finally the divided portions of the external oblique closed by overlapping. If there is much tension in the deeper stitches, a longitudinal incision through the sheath of the rectus muscle will give suitable relaxation. Excellent results have followed this procedure.

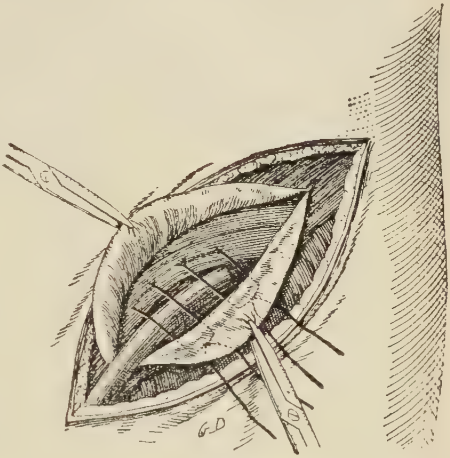

Fig. 515.—Operation for Inguinal Hernia (Carless.)

The inguinal canal is opened up, and the sac removed as high as possible. The cord and cremaster (not represented here) are pressed back and covered over by approximating the internal oblique and transversalis to the under surface of Poupart's ligament by mattress sutures, which are introduced as indicated above, and tied on the outer aspect of the ligament. The divided segments of the external oblique are then overlapped and sutured.

(*d*) For the last few years extensive employment of a somewhat similar proceeding has given most satisfactory results. The canal is opened in the same way, and the sac excised, the ligature being placed as high as possible. The fibres of the internal oblique are

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* *Johns Hopkins Bulletin*, August, 1903.

then exposed by thorough retraction of the divided external; and mattress sutures are introduced through the internal oblique and transversalis, or edge of the rectus sheath, carried across in front of the cord through Poupart's ligament, and tied on its outer surface (Fig. 515). This constitutes a firm muscular barrier across the canal; one or two such sutures usually suffice. The lower or outer segment of the external oblique is then carried up and stitched down to the internal oblique well above the mattress sutures; the inner segment of the divided external oblique is then made to overlap the outer, and stitched down to Poupart's ligament; the deep layer of fascia is also carefully secured by sutures, and the wound closed. Healing almost invariably occurs without suppuration; and even should this happen, the stitches are easily removed, as the knots are on the outer side of Poupart's ligament, and not on the inner, as in Bassini's and Halstead's methods. In all these three methods epididymitis and hydrocele occasionally develop as sequelæ.

The *treatment of direct inguinal hernia* is somewhat different at times, in that the condition usually occurs in elderly men. In many it is wise to order a double truss and avoid operation; but in some operation is permissible. The prognosis is never so good as in the oblique variety—(*a*) because it occurs in older subjects, and is often predisposed to by chronic obesity, cough, or difficulty in micturition; and (*b*) because the chief weakness is at the lower, and not at the upper, end of the canal, and hence the deep ring lies almost directly behind the opening in the external oblique. In these cases experience has taught one that the best plan to adopt is to displace the cord entirely, bringing it out through the muscles opposite the internal abdominal ring, and closing up the rest of the canal completely as in a woman. The more superficial position of the cord does not seem to affect it injuriously.

Recurrence after Operation is much less common than formerly, and statistics go to prove that in experienced hands less than 10 per cent. of the cases recur, and that rarely after the first twelve months. As already stated, it may be due partly to an injudicious selection of cases, partly to errors of technique, and in part to a faulty after-treatment, the patient being given too much liberty at too early a date. In connection with this we would especially emphasize the necessity for isolating the sac as far as possible, since otherwise the infundibuliform opening at the top of the closed peritoneal canal is certain to persist. Another, and that perhaps the most common, cause of recurrence is pyogenic contamination of the wound; if the deep stitches are not involved, no great harm is done, but whenever they have been removed or come away it is wise to use a light truss for a time as a precautionary measure. Again, the mere restoration of a mass of intestine or omentum into the abdominal cavity may suffice to raise the intra-abdominal pressure, and thus predispose to a recurrence; hence the importance of removing as much omental tissue as possible in all bad cases. Relapses may also be due to splitting or tearing of the tendinous structures around, either by the mere passage of the needle, or by the traction induced by tightening the sutures; indeed, it is often the case that a hernia originally oblique may after operation be followed by one that is direct, and probably from this cause.

Whenever it appears likely that recurrence may occur, a truss should be ordered. If, however, a hernia has developed, a second operation may be performed, if the condition of the abdominal parietes warrants it.

Femoral Hernia.—A femoral hernia is one which, travelling down the crural canal, presents at the inner and upper part of the thigh through the saphenous opening. It occurs most commonly in women on account of the greater expansion of the iliac crests allowing increased space beneath Poupart's ligament, and especially in those who have borne children. During parturition the inguinal regions are in a measure protected, and hence inguinal hernia is rarely caused in this way. In young people, however, it is more common in the male sex.

The crural canal constitutes the inner compartment of the femoral sheath, a space usually occupied by fatty cellular tissue, lymphatic vessels, and perhaps a lymphatic gland. It is about ¾ inch in length anteriorly, and 1½ inches along its posterior wall; it is closed above by a thickened portion of the subserous cellular tissue known as the septum crurale, and its lower end is formed by the saphenous opening, and closed by the cribriform fascia. Hence a femoral hernia, as it passes downwards, receives the following coverings: (*a*) peritoneum; (*b*) subserous cellular tissue, including the septum crurale, a layer sometimes known as the fascia propria, and occasionally represented by a thick fatty envelope; (*c*) the anterior layer of the femoral sheath, derived from the fascia transversalis; (*d*) cribriform fascia; (*e*) subcutaneous tissue; and (*f*) skin. In its passage through the canal it is situated immediately internal to the femoral vein, and pressure upon this may produce œdema of the leg, whilst Gimbernat's ligament lies to the inner side. The spermatic cord or round ligament is placed just above and internal to it, but on a superficial plane, whilst the epigastric artery is not very far from the outer side of the neck. Occasionally the obturator artery arises from this latter vessel (once in three and a half subjects); it may pass to the inner side of the neck of the sac along the border of Gimbernat's ligament (once in seventy-five times), but more commonly runs between the neck and the femoral vein. When once it has emerged from the saphenous opening, a femoral hernia usually travels upwards and outwards along Poupart's ligament towards the anterior superior iliac spine, being guided by the attachment of the deep layer of the superficial fascia; when of large size, it may extend considerably above the level of Poupart's ligament. Femoral herniæ are less likely to contain omentum than the inguinal variety: a portion of the ileum is most often present, but occasionally the ovary or Fallopian tube may be found in the sac.

The **Signs** of a femoral hernia are very characteristic. A rounded swelling with an impulse on coughing, and more or less reducible, forms on the inner side of the thigh, its neck or aperture of communication with the abdomen lying to the inner side of the femoral vessels, and to the outer side of the pubic spine, which can always be easily felt (Fig. 516). There is usually but little difficulty in making a **diagnosis,** although occasionally some care is needed. (*a*) An *inguinal hernia* is recognised by the fact that its neck occupies the inguinal canal, the saphenous opening being free; whilst it is also above and internal to the pubic spine, and above Poupart's ligament at its point of exit; it tends to pass downwards into the scrotum, or in females into the labium. Femoral hernia, on the other hand, usually (but not invariably) occurs in women over twenty-five years of age; the inguinal canal is free, whilst the neck is in the situation of the crural canal, below and external to the pubic spine, and below Poupart's ligament; moreover, it travels upwards and outwards, the labium being unaffected. (*b*) An *enlarged lymphatic gland* over the saphenous opening may simulate this condition very closely; but the absence of impulse on coughing and of the usual hernial signs is generally sufficient to distinguish it; when, however, the hernia is purely omental and irreducible, the impulse is so slightly marked that correct diagnosis in a stout woman is often difficult without an exploratory incision. (*c*) A small *lipoma* in the canal somewhat resembles a hernia, but the limitation of the tumour, its greater mobility, and the absence of an impulse on coughing, should suffice to prevent a mistake. (*d*) A *psoas abscess* pointing at the saphenous opening resembles a hernia in the existence of a reducible swelling with an expansile impulse on coughing. It is distinguished from it by the facts that there is no gurgle on reduction; that the abscess, as it passes under Poupart's ligament, lies to the outer side of and behind the vessels; and that distinct fluctuation occurs between the swelling in the saphenous opening and the tumour, which can always be felt in the iliac fossa; the characteristic signs of spinal caries are also usually present. (*e*) In *varix of the saphena*, if a pouch or ampulla forms close to its entrance into the femoral vein, it may be mistaken for a femoral hernia on account of the marked impulse on coughing, and because the swelling disappears on assuming the recumbent position. It is, however, usually associated with the signs of varix below, and by the fact that, although pressure is maintained over the upper part of the crural canal after the vein has been emptied, the swelling regains its ordinary size when the patient stands up. The impulse

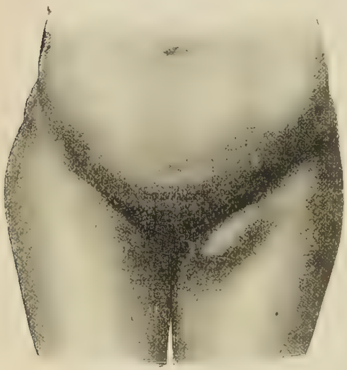

FIG. 516.—FEMORAL HERNIA.

is of a different character to that of a hernia; the blood can be felt to be driven past the examining finger with a thrill, instead of there merely being an expansile bulge.

Treatment.—When reducible and of small size, a femoral hernia may be treated by the use of a *truss*, similar in nature to that used for an inguinal hernia, except that the pad extends somewhat lower, so as to maintain pressure along the course of the canal. A badly-fitting truss may compress the femoral vein, and lead to œdema of the leg.

Operative Treatment is undertaken either for the relief of strangulation, or, if a radical cure is desired, as an *opération de complaisance.* The remarks already made as regards the cure of inguinal hernia, and the general principles there enunciated, apply also to this variety. The apposition of the anterior and posterior walls of the crural canal is the essential element in the operation, and this practically resolves itself into the fixation of the inner end of Poupart's ligament to the horizontal ramus of the pubis or the structures overlying it. The sac is exposed by a vertical incision along the course of the crural canal (Fig. 473, G), cleared of its fatty covering, which is often thick and abundant, emptied of its contents by reduction, and then cut away after transfixing and tying the neck. Some surgeons, however, retain the sac, pushing it back into the abdomen, and using it as a pad across the upper opening of the canal. The fatty covering of the sac must be dealt with in a similar way. The deep ring is then commanded by one of the following methods: (1) In the great majority of cases it will suffice to introduce stitches through the inner end of Poupart's ligament (Fig. 517), and deeply through the horizontal fibres of Cooper's ligament, which lie in close apposition to the horizontal ramus of the pubis. There are but few cases where this manœuvre, if effectively carried out, is not sufficient to determine closure of the canal; but for this purpose the hernia needle must be carried down to the bone, and not merely through the fascia over the pectineus. (2) In a few cases, perhaps, where the opening is larger, it may be desirable to approxi-

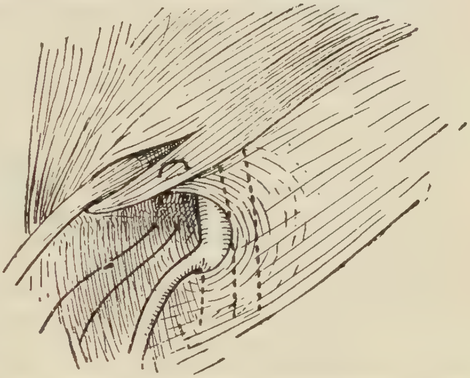

Fig. 517.—Diagram of the Radical Cure for Femoral Hernia.

The position of the femoral vein and artery is indicated, and the internal saphena vein passes up through the saphenous ring to join the former. The spermatic cord is seen above, and the situation of the suture to close the crural canal.

mate Poupart's ligament to the horizontal ramus by some other method, and for this purpose Roux has advised the use of a ∩-shaped metal staple, which traverses the ligament, and the free ends of which are driven into the bone. This plan appears to us undesirable, since the staple occasionally works loose, and then the proximity of the femoral vein makes it an unwelcome neighbour. (3) A good substitute for this plan has been practised by Nicoll* of Glasgow, who drills the horizontal ramus from below upwards in two spots, and then by passing a mattress suture through Poupart's ligament and the free ends through these drill-holes, tying them below, the ligament is safely approximated to the inner and upper aspect of the pubis.

Umbilical Hernia.—Three different forms of umbilical hernia are described.

1. **Congenital Umbilical Hernia, or Exomphalos,** is an exceedingly rare condition, due to imperfect closure of the abdominal walls, as a result of which part of the intestine is found at birth in a cavity at the base of the umbilical cord, which is bulbous and enlarged. If the condition is overlooked, it may be included in the ligature with which the cord is tied, and fatal strangulation, or at the best a fæcal fistula, will result. If left untreated until the cord has separated, the peritoneal cavity will be laid open, and septic peritonitis ensue. The only *treatment* is immediate laparotomy, reduction of the gut, and closure of the umbilical opening by sutures, if such be possible.

2. The **Umbilical Hernia of Infants and Young People,** or, as it is commonly called, 'starting of the navel,' is due to weakness of the umbilical cicatrix, which yields before the intra-abdominal pressure. Its occurrence is often determined by chronic constipation or phimosis, necessitating continual straining in order to evacuate the bowels or bladder. The condition rarely persists till adult life, as it is easily cured. *Treatment* consists in regulating the bowels and in the performance of circumcision, if necessary, whilst the local condition is dealt with by strapping the abdominal wall in such a way as to tuck the umbilical cicatrix inwards; no pad is required. In persistent cases it may be necessary to lay the sac open and remove it, suturing the parts together, as described in detail below. In these cases the opening is often a transverse chink rather than a round hole, and it is sometimes advisable to introduce the sutures in a vertical direction, thereby securing transverse apposition.

3. The so-called **Umbilical Hernia of Adults** is usually due to a protrusion of omentum or intestine through an opening in the linea alba, either immediately above or below the umbilicus, the former being the more common. It occurs most frequently in women who have borne children, being sometimes due to actual rupture of the linea alba and separation of the recti muscles. A peritoneal sac is present, but in old-standing cases it is extremely attenuated, and so adherent to surrounding parts as to be unrecognisable, whilst the contents may be matted together in an almost inextricable

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* *Scottish Med. and Surg. Journ.*, December, 1903.

confusion. Under such circumstances obstruction is very liable to ensue, and if combined, as is not uncommon, with a subacute form of inflammation, it may even run on to strangulation. Moreover, the skin over the tumour becomes stretched, atrophic, and not unfrequently ulcerated, so that perforation may threaten. The hernia is often lobulated in character, and a considerable deposit of fat may sometimes surround it.

Treatment.—When of large size, and occurring in stout individuals, it should be supported by a bag truss, whilst the patient is placed on such dietetic and hygienic measures as shall assist in the reduction of excessive corpulency. In favourable cases operative treatment can be undertaken. A vertical incision is made over the site of the tumour, and to effect this without wounding the subjacent gut, it may be advisable to pinch up the skin on either side, and divide it by transfixion. The sac is then opened, the incision being enlarged, if necessary, so as to allow the contents to be drawn aside and the opening in the abdominal wall exposed. When the intestine has been reduced and omentum removed, the sac is dissected up to the margins of the opening into the abdomen, which is usually small in size and circular in shape, whilst the edges are firm and thickened. The sac may now be cut away close to the opening, and all bleeding-points secured. The aperture is then closed in the following way: Several deep transverse sutures are passed through the whole thickness of the abdominal wall on each side and tightened, after a row of interrupted sutures has drawn the peritoneal surfaces into contact. By this means the circular aperture is obliterated and the margins united in the median line. The external wound may now be closed, any redundant skin being cut away; it is usually safer to insert a drainage-tube in the more extensive cases.

Most surgeons have discovered by experience that such a procedure is insufficient in any but the slighter cases, and that a much more radical operation is required when the hernia is large and irreducible, and the patient at all inclined to corpulence. (1) The early steps of the operation are identical, but it will be found advantageous to place the cutaneous incision to one side of the tumour rather than over its centre. The freeing of the omentum may be a matter of great difficulty, as it is often adherent to the margins of the opening. (2) It will then be found that the anterior layer of the sheath of the rectus is prolonged over, and soon lost on the sac. An incision is made all round the neck of the sac through this aponeurotic covering to reach down to the subperitoneal tissue; stitches are now introduced across the opening through the peritoneum and this detached ring of aponeurotic tissue in order to effect its closure (Fig. 518); all redundant sac is clipped away with scissors, bleeding-points being secured. (3) The recti muscles are now laid bare on either side, and their posterior surfaces and edges loosened so that they, together with the anterior layer of their sheaths, can be brought into apposition over the closed neck of the sac, which is thereby buried. To do this effectively the incisions may have to be prolonged up and down the abdominal wall for some distance, since the recti are usually displaced outwards some way above and below the opening. Silkworm gut may be advisably used to bring the margins together. Redundant skin is now cut away with a free hand, so that the abdominal integument may not be unduly lax, but shall just cover the muscles comfortably. In stout patients this may involve the removal of considerable masses of fat.

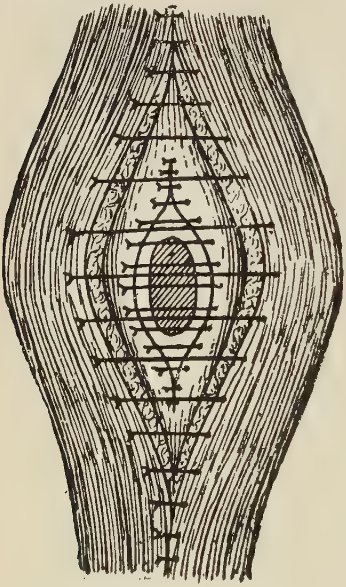

FIG. 518.—DIAGRAMMATIC REPRESENTATION OF THE RADICAL CURE OF AN UMBILICAL HERNIA WHERE THE RECTI MUSCLES ARE CONSIDERABLY DISPLACED.

The short cross-lines represent the sutures which close the opening in the peritoneum; the long ones, the sutures needed for apposing the edges of the recti muscles and the anterior walls of their sheaths.

An operation of this type is a severe one, and not to be lightly entered upon; but if it is carefully conducted, the results in many cases are most successful. Of course it is very desirable that the abdominal wall should afterwards be supported by firm strapping for some time, and that no undue strain should be placed upon it.

A **Ventral Hernia** is the term used in describing any protrusion occurring at some spot in the anterior abdominal wall other than those already mentioned. Several forms may be met with:

1. It consists not uncommonly of a protrusion of subserous, fatty tissue through a congenital or acquired opening in the linea alba, lineæ semilunares, or lineæ transversæ, especially at the junctions of the last with the former. They are more common above than below the umbilicus, and if, as not unfrequently happens, the fatty tissue proliferates, a localized tumour resembling a lipoma is produced, which goes by the name of a *fatty hernia of the linea alba.* A portion of peritoneum is drawn through the opening into the centre of these masses when they have persisted for some little time, and a true hernia is thus induced. A similar condition is met with in the inguinal and crural regions, and probably most of the cases described as lipomata in these parts are of this nature. Considerable pain and abdominal disturbance (vomiting, colic, etc.) accompany almost every movement of the body, being caused partly by the traction of the peritoneum, partly by the constriction of the neck of the sac against the sharp edges of the small opening. *Treatment* consists in the removal of the projecting mass, care being taken not to include any viscera in the suture with which the base is surrounded

The stump is pushed back into the abdomen, and the opening closed by deep sutures.

2. After operations involving the division of the abdominal parietes, ventral hernia may be caused by the yielding of the cicatrix, especially if the wound suppurates, and the deep stitches come away or are removed, or if the opening is left patent for the purpose of draining an intra-abdominal abscess. *Treatment* of such cases consists in dividing the skin and subjacent fibrous tissues, defining and refreshing the edges of the parietal wound, and drawing them together with buried sutures. Whenever possible, however, the object of the operation should be to overlap the margins of the opening by the use of mattress sutures, bringing surface to surface rather than merely edge to edge. A little more manipulation and freeing of the parts is necessary, but it is astonishing to note what extensive gaps in the abdominal wall can be effectively cured in this way. Sometimes, however, the defect is too extensive for treatment in this manner, and then the surgeon may advisably utilize a *silver filigree*, which is implanted across the opening on a level with the subperitoneal tissue. Of course it is effectively sterilized before use, and forms a permanent barrier against further hernial protrusions.*

3. In women who have borne children the linea alba often stretches and yields, allowing considerable separation of the recti muscles for almost their whole length. If placed in the recumbent posture, and told to raise their head and shoulders from the bed without using their elbows for support, the linea protrudes as a longitudinal ridge of considerable breadth. Much discomfort and dyspepsia arises from this cause, owing to the inefficient support given to the intestines. A firm abdominal belt may be used as a palliative measure, but operation is very desirable. The thinned linea alba is split down the middle from top to bottom if need be; on one side—say, the right—it, together with the neighbouring rectus muscle, is separated from the subcutaneous tissues and tucked under the rectus on the left side, its free end being secured by a row of mattress sutures passing through its edge and the left linea semilunaris, and being tied superficially. The left free edge is subsequently secured to the right linea semilunaris by a row of stitches. Redundant fat and skin is removed, and the wound closed by sutures. In this way the abdominal wall is drawn together like a double-breasted coat, and excellent results follow.

A **Lumbar Hernia** is a condition of considerable rarity, in which the abdominal viscera protrude by the side of the erector spinæ, coming to the surface between the latissimus dorsi and the external oblique, in the space known as Petit's triangle. It is perhaps seen most frequently after operations upon the kidney where suppuration has occurred, and the deep stitches have had to be removed. The ordinary signs of hernia are present, and with a little care the condition is readily distinguished from a lumbar abscess. *Treatment* may be conducted along the same lines as for a ventral hernia.

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* MacGavin, *Practitioner*, August, 1906.

A **Diaphragmatic Hernia** is rarely recognised *ante-mortem*. A few cases of strangulation have, however, been diagnosed. It is usually congenital in origin, arising from imperfect development of one or both halves of the diaphragm, and is most common on the left side, It may, however, result from traumatic lesions, such as stabs, involving the diaphragm. The transverse colon or stomach generally protrudes into the thorax, and there is usually no peritoneal sac. *Treatment* is impracticable in the majority of instances, although one or two cases of traumatic hernia have been successfully operated on through the chest wall and pleural cavity, thus permitting the closure of the hole in the diaphragm.

Obturator Hernia consists in a protrusion of intestine through the upper part of the thyroid foramen, and has usually been observed in elderly females. It is not often recognised in the living, except when strangulated, and even then it is more likely to be discovered from the abdominal aspect during a laparotomy for acute obstruction than diagnosed apart from operation. In a few cases, however, it has been noted that, in addition to the general signs of strangulation, there was a sense of deep resistance and of fulness close to the origin of the adductor muscles; whilst pain was referred down the obturator nerve to the inner side of the knee. Rectal or vaginal examination may throw some light on the nature of the case. *Treatment* has generally been confined to cases of strangulation, and in these an incision is made over the inner aspect of Scarpa's triangle, and the pectineus divided or displaced. The sac when found should be opened, and strangulation relieved by cutting upwards, the obturator vessels being usually situated below the neck of the sac. If found during a laparotomy for obstruction, the same precautions must be taken as for a Richter hernia in the femoral region when discovered in the same way (p. 1123).

Other forms of hernia—*e.g.*, **pudic, pudendal, vaginal, sciatic,** etc.—have been described, but are so uncommon that they need no special mention.

Abnormal Conditions of Herniæ.

Irreducibility of a Hernia is generally due to the presence of adhesions, either between the contents and the sac, or between the contents themselves, which are thus united into a mass too large to pass through the aperture of communication with the abdomen. This is often associated with contraction of the neck of the sac, which arises either from the pressure of an ill-fitting truss or the constant drag of the contents. Overgrowth or an excessive deposit of fat in the omentum may result in irreducibility, whilst cysts may occasionally form, as already described.

The local signs of this condition are very evident, whilst dyspepsia, colicky pains, and a sense of dragging are among the most prominent symptoms.

Treatment.—1. It may sometimes be remedied by *forcible taxis* applied at intervals, between which the patient is kept in bed, and an icebag applied so as to contract the parts; moreover, the patient, if fat, should be carefully dieted. It is most important not to operate on large herniæ of this nature until some such preliminary treatment has been undertaken; the sudden reduction of a large amount of intestine into the abdominal cavity has been responsible for several deaths from interference with the heart's action. 2. Another plan consists in the use of what is known as the *hinged-cup truss*; the hernia is supported in a suitable leather bag hinged to the lower part of a truss, upward pressure being maintained by means of an elastic spring. By the use of one or other of these plans reduction may after a time be accomplished; but we are not in favour of any such proceedings, except in very large herniæ. 3. In healthy individuals, and if the rupture is not too large, operation is preferable and much more satisfactory, omentum being removed and adhesions divided, as already described. 4. In a few very aggravated cases, it is only possible to support the hernia by an elastic bag.

Inflamed Hernia is one characterized by the existence of a localized peritonitis involving the sac, and perhaps also the contents. It usually arises from injury, such as ill-directed taxis, or from injudicious truss pressure. The symptoms are those of a local inflammation, the part becoming hot, painful, tender, and swollen, and perhaps the skin over it congested; this is associated with general fever, malaise, nausea, and vomiting, whilst constipation is generally present. A condition is thus induced somewhat resembling strangulation; but it is distinguished from the latter by the presence of fever instead of shock, the absence of tension in the sac, and the character of the vomiting, which is not fæcal. The hernia is irreducible, at any rate for a time, probably more on account of the pain, which prevents taxis, than from any mechanical reason, except in old-standing cases where previously formed adhesions exist. Lymph is deposited on the serous surfaces, and this usually leads to the formation of adhesions. Occasionally, where omentum is alone present, an attack of this type may result in a natural cure, especially in the umbilical variety.

The **Treatment** consists in putting the patient to bed and restricting his diet to fluids, whilst fomentations are applied to the part. A little opium may also be administered to allay the pain, and the lower bowel is emptied by an enema. Should the condition persist in spite of treatment, it will be wise to operate, as otherwise strangulation might follow.

Obstructed Hernia is a condition in which the onward passage of fæces through the gut contained in a hernial sac is prevented. It is most frequently seen in the umbilical variety, and, of course, only involves the large gut. It is due to an accumulation of undigested food or fæces, the condition being aggravated by the presence of flatus derived from the decomposition of the contents of the bowel. Nausea and vomiting are induced, the latter, however, rarely becoming fæculent, whilst constipation is usually present, although the lower bowel may empty itself and flatus may pass. Locally, the tumour becomes irreducible and distended, but not tense as in strangulation, and a doughy mass, which can be moulded and indented by the fingers, is felt within the sac. There is no tenderness, but the patient complains of a good deal of intermittent colicky pain. If unrelieved, a subacute form of inflammation may supervene, and this may pass on to strangulation, and even death.

Treatment consists in the use of copious enemata, and the application of an icebag to the hernia, followed by carefully-applied taxis, so as to assist the onward passage of the impacted contents. As soon as the obstruction is overcome, a brisk purge should be administered.

Strangulated Hernia.

A hernia is said to be strangulated when the contents are constricted in such a way as to obstruct and ultimately to arrest the flow of blood in the vessels contained therein. Interference with the passage of fæces is not an essential in this condition, since omentum alone may be involved, or the intestine, if present, may only have a portion of its lumen constricted, as in the form known as **Richter's hernia** (Fig. 519), whilst in **Littré's hernia** a diverticulum is similarly affected.

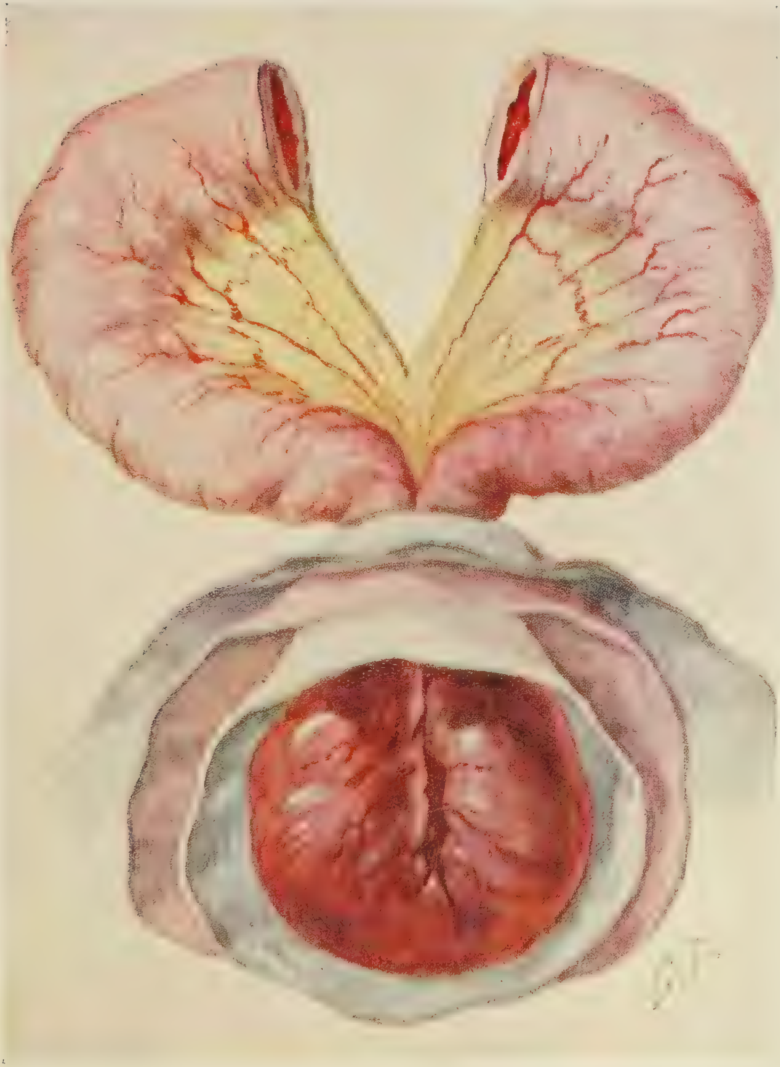
Two chief varieties of strangulation are described: those occurring within the abdomen, which are dealt with more fully in Chapter XXXVII., and those which are extra-abdominal; it is only the latter to which we shall now direct attention.

External Strangulated Hernia arises in one of two ways: (*a*) The hernia becomes strangled immediately after its formation; this is most frequently seen in children or adolescents, the hernia being then of the congenital type, and having a long narrow sac. (*b*) In adults it more frequently results from extrusion of an additional amount of the abdominal contents into the sac, as the outcome of some sudden violent effort. This condition usually obtains in old-standing herniæ, the neck of the sac having previously become thickened and contracted, either by the pressure of a truss or the irritation of the protruded viscera. The former of these two conditions is generally acute in character, the latter more often subacute.

The site of the constriction is either at the neck of the sac, or in the dense tissues external to it (Plate X.), but occasionally it exists elsewhere. Most frequently the active agent in the strangulation is the thickened sac wall itself; but in femoral and umbilical herniæ structures outside the sac, such as Gimbernat's ligament or the linea alba, may be the actual cause of the constriction, whilst it may also be produced by the passage of a coil of intestine under a tight adhesion or through a slit or aperture in the omentum contained in the sac. In those herniæ which become strangulated immediately after their protrusion, the constricting cause is invariably the resistance of the tissues surrounding the opening in the abdominal parietes.

Pathological Phenomena.—The effects of strangulation vary somewhat with the tightness of the constriction. The circulation is seldom

PLATE X.



Strangulated Hernia.

[*To face page 1112.*

arrested entirely at the onset of the symptoms; but the pressure affects first, and, more especially, the veins, and later, by the congestion and exudation thus produced, the flow in the arteries is brought to a standstill. Hence the constricted tissues are congested to begin with, and then, partly as a result of the deficient supply of arterial blood, mainly in consequence of bacterial invasion, gangrene ensues, with or without an intervening period of inflammation.

When a *portion of intestine* is strangulated, it first becomes of a dusky red, chocolate, or claret colour, owing to vascular congestion; it is thickened and stiff from exudation into its walls, and distended by the formation of gas within its lumen, owing to the arrest of peristalsis and the putrefaction of its contents. The surface for a time remains smooth and shiny, but as the exudation into the sac increases, the endothelium is shed. Occasionally some of the superficial capillaries rupture, giving rise to ecchymoses, whilst in rarer instances, and possibly as the result of injudicious taxis, the congested vessels completely empty themselves into the sac, which is thus filled with clotted blood, the intestine in consequence becoming lax and yellowish-grey in colour. When the strangulation is relieved in this early stage, the bowel soon regains its former healthy appearance. If inflammation occurs, the surface becomes rough from the deposit of lymph, and entirely loses its shiny and polished aspect. Gangrene results partly from the prolonged stagnation of blood, and partly from the invasion of the intestinal wall by the *B. coli* and other anaërobic inhabitants of the gut, which, as soon as the vitality of the intestinal wall is sufficiently impaired, migrate through it, and by their development produce toxic bodies which still further assist the gangrenous process. As soon as it is established, the intestine turns an ashy grey or black colour, usually at one or more spots which gradually spread, lose all lustre and polish, and after a time become soft, lacerable, and offensive. Gangrene* is much more common in the femoral and umbilical forms of hernia than in the inguinal; it is generally developed in two or three days, but occasionally may supervene in less than twenty-four hours from the onset of the strangulation. It is more often seen in small herniæ of recent origin than in large old-standing ones. *At the point of strangulation* the gut is completely anæmic and liable to ulceration or gangrene, which may subsequently result in perforation; adhesions may, however, form between it and the neck of the sac, thus preventing contamination of the general peritoneal cavity. The intestine *above the site of strangulation* becomes paralyzed, and peristalsis is entirely arrested, even in a Richter's hernia. Fæcal material, accumulating and undergoing decomposition, gives rise to a catarrhal enteritis, and even occasionally to stercoral ulcers, which may perforate and cause general peritonitis; this, however, is not very common in external strangulation, since the small intestine is usually involved, and solid fæces are absent. In more chronic cases gangrene of the gut may be induced by the pressure of the accumulated contents and the action of the *B. coli*. The portion of the bowel *below the constriction* may be affected in a similar manner, owing to the arrest of the peristalsis, but to a slighter degree.

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* For a valuable paper on 'Gangrene in Strangulated Hernia,' see Corner, St. Thomas's Hospital Reports, vol. xxix.

Omentum, when strangled, is at first congested and of a dark red or purplish colour, and later on infiltrated and matted together. If, however, it has contracted adhesions to the sac, and no gut is present, the trouble may subside, since its vitality may be maintained through the adhesions, and a natural cure of the hernia may result. Where such a condition is not present, gangrene supervenes, and the omentum then becomes ashy gray or brown in colour, and is pultaceous and friable. It does not become offensive unless associated with intestine, since it does not contain any intrinsic source of putrefaction.

The *sac* is usually distended with fluid, which at the commencement is serous in character, and perhaps blood-stained, whilst subsequently it becomes turbid and mixed with lymph; finally, it is dark brown or yellowish-green, with a marked and most objectionable odour. Sometimes there is but little or no effusion of fluid, a condition generally due to complete strangulation of arteries and veins simultaneously, and often the precursor of early gangrene. The serous lining of the sac is but slightly affected in the early stages; as, however, the case progresses to inflammation or death of the contents, it also becomes inflamed, and ultimately gangrenous from the activity of bacteria, which by this time have penetrated to the turbid serum contained within it. The skin and surrounding tissues become œdematous, congested, and crepitant, and, finally, a natural cure may be determined by sloughing and the establishment of an artificial anus.

After the relief of strangulation, even if no gangrene has occurred, the patient is not free from risk, owing to changes which may possibly follow the temporary arrest of the circulation, since the prolonged blood-stasis in the bowel may be followed by inflammation, owing to the damage done to the vessel walls, or by gangrene, owing to the diminished vitality of the bowel wall rendering it more vulnerable to the attacks of the intestinal bacteria.

The **Clinical History** of a case of strangulation is usually so characteristic that there can be but little uncertainty as to the diagnosis. The *general* symptoms are similar to those described at p. 1127, as occurring in all cases of acute intestinal obstruction. The patient during some sudden effort notices a severe pain, localized at first to one of the hernial regions, or referred to the umbilicus; this is accompanied by the usual evidences of shock—*i.e.*, he feels faint, the pulse becomes slow and weak, the temperature falls, and the surface is covered by a cold, clammy sweat. This shock is often not very prolonged, and is associated with or quickly followed by vomiting, at first gastric, then bilious, and finally stercoraceous or fæcal. As this continues, the pain increases in severity, and radiates over the whole of the abdomen, which becomes tense, tender, and tympanitic.

Symptoms of exhaustion supervene, caused partly by the pain and vomiting, and partly by the inability to take food; probably the absorption of toxic material from the intestines also assists in its production. Complete constipation is usually present, but the patient may pass flatus or fæces from the lower part of the intestine. The onset of gangrene is generally accompanied by a sudden fall of temperature and a cessation of pain, whilst the pulse becomes weak, rapid, and intermittent, the surface is covered by a cold sweat, the countenance becomes shrunken and drawn (the so-called *facies Hippocratica*), hiccough follows, and finally the patient dies, usually as a result of toxæmia due to the absorption of products developed either in the bowel wall or sac, or in consequence of acute generalized peritonitis.

Locally, a tumour is found in one of the usual sites of a hernia, or if already the subject of this condition, the patient may notice that his rupture has suddenly become larger. The swelling is irreducible, tense, extremely tender and painful, and without impulse on coughing. It is hard and rounded if bowel is involved, softer and more doughy to the touch, if omentum. When gangrene ensues, the tension within the sac is reduced, pain and tenderness cease, whilst the skin over the tumour becomes dusky, inflamed, and œdematous; finally, evidences of gangrene show themselves externally, the parts becoming dark in appearance, and soft and emphysematous to the touch. If the patient survive, the necrotic tissues separate, and an artificial anus is produced either naturally or through the intervention of the surgeon. Suppuration within the sac is uncommon.

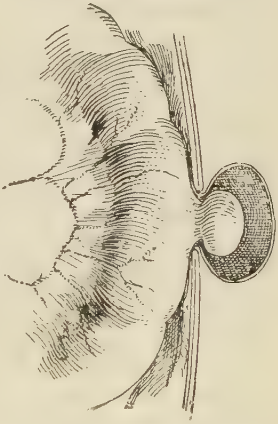

FIG. 519.—RICHTER'S HERNIA. (DIAGRAMMATIC.)

Occasionally, however, cases are met with in which the above-described signs are considerably modified, and gangrene of the gut may occur without the exaggerated phenomena of a serious toxæmic type indicated above. In one case the patient complained of no inconvenience beyond slight pain, although incipient gangrene was present; he walked into hospital saying that he never felt better in his life.

The early symptoms arising from strangulation of a portion of the lumen of the intestine (*Richter's hernia*, Fig. 519) are sometimes less marked than when a complete loop is constricted, but the later phenomena are always very severe. It is usually of the femoral variety, and the ileum is most frequently involved. If less than half the circumference of the bowel is constricted, the obstruction is not always complete at first, flatus and fæces being sometimes passed; but where more than half the circumference of the bowel is engaged, complete obstruction from kinking or paralysis of the gut ensues. The vomiting is less marked than in other cases, and is not so commonly fæculent. The tumour produced is small in size, but tense and tender. It is quite possible, however, for it to be overlooked, even when the groin is examined, and the diagnosis is then likely to be made either on the operating or post-mortem table. The prognosis in these cases is always grave, partly from the difficulty experienced in diagnosis, partly from the tightness of the constriction; death usually results from perforative peritonitis, which is occasionally due to wounding of the gut by the hernia knife. The mortality in these cases is calculated at 62 per cent., which is in marked contrast with that of about 35 per cent., which is usually said to be characteristic of strangulated hernia. The mortality for all cases of strangulated hernia admitted to King's College Hospital during the years 1892 to 1897 only amounted to 16·6 per cent.

The occurrence of *strangulation in a pure epiplocele* is very rare; the symptoms are vague in character, and the diagnosis is often difficult. The presence of a soft, doughy, tender swelling in any of the hernial regions, combined with pain, bilious vomiting, and possibly constipation, is always a significant feature. So long as no kinking of the bowel is caused thereby, the symptoms may remain indefinite, the vomiting never becoming fæcal; but as time goes on, arrest of peristalsis may lead to true obstruction, or even general peritonitis. As already mentioned, strangulated omentum does not *per se* become offensive; but occasionally a neighbouring coil of intestine may be dragged upon, and its circulation disturbed sufficiently to enable the *B. coli* to escape, and then it may find its way into the sac, and an infective inflammation may result.

The **Treatment** of a strangulated heinia consists in reducing the contents by taxis, or by operaiton.

Taxis is the term employed for the manipulation by means of which a hernia is reduced. In cases of strangulation, it must be used with gentleness and great care, since the involved portion of intestine is congested and easily torn. The patient is laid on a couch with the head supported and the thighs slightly flexed, so as to relax the abdominal muscles. The fundus of the tumour is then grasped with one hand, and steady pressure employed, having for its object the emptying of the congested bloodvessels, and consequently a diminution in the size of the hernia; the fingers of the other hand manipulate the neck of the sac, in order that the part which has most recently been protruded may be first returned. The direction in which taxis is made varies in different cases. In inguinal hernia, it should be directed upwards. outwards, and backwards, In a femoral hernia which has extended beyond the saphenous opening, taxis is first employed downwards and inwards in order to make the gut re-enter the crural canal, and then finally backwards and upwards, the margins of the saphenous opening being relaxed by flexing and slightly inverting the thigh. In umbilical hernia, the pressure is mainly directed backwards.

It must be admitted that in the past taxis has often been used injudiciously and in cases where it could not be expected to do any good; the bowel has sometimes been ruptured or its wall bruised, the mesentery torn, and other serious results have followed. At the present day operative treatment for hernia is eminently successful, and open exploration of the sac enables one to judge of the condition of the gut and prevents the likelihood of returning to the abdomen an infected and even gangrenous focus. Hence it may be stated that *taxis is permissible* when the hernia is of large size, particularly if inguinal, when the symptoms have a mild onset and do not become severe, and especially if taxis has been successful on former occasions. It may also be employed in old people with diabetes or albuminuria, or in insanitary surroundings. *Taxis is objectionable,* and if employed at all should be used very cautiously, when the hernia is small and tense, and particularly if femoral; when the onset is acute and sudden; when the symptoms are well marked, and especially if they become so in the early stages of the case; if strangulation follows on the first development of the hernia; and of course if the case has lasted for some time and fæcal vomiting is present. A final attempt may always be made before operation when the patient is anæsthetized.

In some of the slighter and earlier conditions of strangulation, and especially if the patient has had similar attacks before which have been relieved without operation, reposition may be assisted by applying fomentations for half an hour, followed by the use of an icebag, reduction sometimes taking place spontaneously or being brought about by taxis. The heat relaxes the tissues around the neck of the sac, and the effect of the cold is not only to constrict these tissues, but also to induce contraction of the intestinal blood-vessels and muscles.

Persistence of Symptoms after Apparently Successful Taxis.—It happens occasionally that although the surgeon may have apparently reduced the hernia satisfactorily, the symptoms of strangulation—viz., pain, vomiting, and constipation—persist. Such may be due to a variety of conditions, and considerable judgment is needed in coming to a correct decision in any particular case. (i.) Infective gangrene may involve the released coil of gut and spread to the portion above it, causing death from peritonitis and toxæmia. (ii.) Ulceration and perforation may occur along the 'constriction groove.' (iii.) The rupture reduced may not be the one which has given rise to the symptoms, an internal hernia, or one in some other region, co-existing. (iv.) The strangulation may have been caused, not by the neck of the sac, but by a slit in the omentum contained in the sac. Reduction in such a case would not relieve the symptoms, the whole mass being returned into the abdomen. (v.) A *volvulus* may have been present, either wholly or partly in the sac, and may have been reduced untwisted. Occasionally a volvulus is produced by the manipulations of reduction, especially when the mesentery has been lengthened in long-standing hernia and the bowel paralyzed by the strangulation. (vi.) The hernial sac may have a diverticulum or pocket communicating with it at its upper end (intraparietal interstitial hernia), or it may be shaped like an hour-glass. It is possible to reduce the intestine from the lower portion of this so-called *hernia en bissac* into the upper pocket, and then of course the symptoms persist. (vii.) Reduction *en bloc* or *en masse* ought never to be seen, as it can only occur when considerable, and therefore an unjustifiable amount of force has been employed. The sac and its contents are together reduced from their superficial position to the deep aspect of the abdominal parietes, the hernia then lying between the muscular planes or in the subserous areolar tissue, and the constriction remaining. The hernia gradually disappears, but without the characteristic gurgle. In such a case the sac sometimes gives way, the intestine and the portion of the neck which compresses it being pushed upwards. When occurring in the inguinal region it is recognised by the persistence of symptoms, and by the fact that a finger inserted into the canal, which is unduly patent, detects a tense rounded swelling at its upper end. It also happens, but less commonly, in the femoral region, and in either variety the hernia may slip down again a short time after its apparent reduction.

In any case where, after an apparently successful taxis, the symptoms of strangulation are still present, a most careful investigation is needed in order to ascertain, if possible, the cause. Thus, the character and frequency of the vomiting must be considered, since it may be due to the anæsthetic, but then loses its fæcal character, and is less severe. If the vomiting is associated with a certain amount of local pain, and possibly with some blood-stained diarrhœa or the passage of mucus, the probability is that the coil of gut has been in reality reduced, but has subsequently become inflamed. Apart from such indications the affected region must be thoroughly explored with the finger, so as to ascertain whether any tumour can be felt at the upper or deeper end, as occurs in reduction *en masse*. Should this throw no light upon the case, the other hernial apertures must each in turn be examined, and finally an incision is made over the supposed site of strangulation, and an exhaustive search made for the sac. If no help is thus obtained, the abdomen must be opened, and some internal complication sought for. In the inguinal region, all that is needed is to prolong the first incision upwards and outwards; in a femoral hernia, it is perhaps wiser to make a separate abdominal incision in the middle line, so as to avoid the division of Poupart's ligament; whilst in the umbilical variety, the requirements of the case are met by simply increasing the size of the communication between the sac and the abdominal cavity.

The **Operative Treatment** of strangulated hernia should always be undertaken at as early a date as possible, when once it is certain that the bowel is constricted. Nothing can be gained by waiting, whilst even the delay of an hour may make it doubtful whether the result will be successful or not. There is always sufficient time to permit of efficient purification of the parts, and it may be desirable to empty the lower bowel by an enema, or if there is much vomiting to wash out the stomach. The administration of an anæsthetic needs care, and in the worst cases local anæsthesia or spinal analgesia must be depended on. A suitable incision is then made down to the sac, which should be recognised by its tense and rounded outline. It is isolated as far as possible from surrounding structures, and then carefully opened. The amount of fluid varies much, and is sometimes very small, so that the possibility of injuring the bowel must be kept in mind. Having given exit to the fluid from the sac and noted its characters, the surgeon carefully examines the bowel or omentum. The cause of strangulation is then looked for and divided by a special hernia knife, which practically consists of a curved blunt-ended bistoury, the cutting blade being limited to an extent of about ¾ inch from the blunt end. If such is not to hand, an ordinary blunt-ended curved bistoury will suffice. The index-finger is employed to repress and guard the intestine, and acts better than a director, since intestine is likely to curl up on either side of the instrument, and may thus be injured. The knife is then slipped on the flat under the constriction, and turned so as to divide it; it is better to nick it slightly in two or three places than to incise it by one deep cut.

The gut is carefully drawn down into the wound, and its condition at the site of strangulation examined; it is sometimes a matter of difficulty to decide whether it should be returned or not. Of course when gangrene is obviously present further treatment is necessary; but in many cases the condition of the bowel is doubtful. It is then well to delay action for a few minutes, and perhaps douche the parts with warm salt solution. A gradual change of colour from a deep claret to a more definite red indicates that the circulation is still active; occasionally, however, it will be found that no change occurs in spite of division of the constriction, or that the admittance of the circulation brings into evidence here and there patches that remain unaltered; these are probably gangrenous, and it is wise to deal with them as such. Omentum, if small in amount and recently prolapsed, may be reduced, but it is better practice to remove any congested portion, or that which has evidently been in the sac for some time. The method of its removal has been already described (p. 1098).

According to the condition of the intestine, the further steps of the operation are modified as follows:

1. If the gut, though congested, shows no sign of gangrene or perforation, it may be safely reduced. This is not always a matter of ease, owing to the fact that the effusion into its walls has made it stiff and firm. Prolonged and steady pressure with the fingers will, however, sufficiently remove the exudation to permit of its reposition into the abdomen. All manipulation directed to the intestine must, of course, be of the gentlest nature, since its congested state makes it more friable than usual.

2. If the gut has been tightly strangled and gangrene is threatening, it is advisable to resect it at once, the incisions being made well above and below the sites of constriction; the divided ends are united by one of the plans detailed at p. 1037. If, however, the bowel is in a doubtful condition, but recovery thought possible, it is gently replaced just inside the abdomen, after freely dividing the constriction, and a large drainage-tube is inserted down to it. There is no need to fix the bowel; it is already inflamed and paralyzed, and hence will not change its position, especially if a small dose of opium is subsequently administered. In this way, even if gangrene or perforation occurs, a track is left for the escape of the contents, while a localized plastic inflammation will shut off the general peritoneal cavity. A fæcal fistula may thus be formed, but it often closes spontaneously at a later date.

3. If the gut at the time of operation is evidently gangrenous, the ideal treatment consists in (*a*) *total removal of the affected coil*, and of some inches below and above it, especially the latter, so as to be well clear of the infected focus. The ends are united together in the usual way, and a considerable degree of success may be expected in patients who have not been left too long. The intestinal canal is at once restored to functional utility, so that the fluid and offensive fæcal material can pass onwards, whilst the absorption of toxins from the stinking gangrenous gut wall is stopped. (*b*) In only too many of these cases, however, the general condition is almost hopelessly bad through delay, and primary enterectomy, even in expert hands, takes some time. It is then necessary to open the bowel and make an *artificial anus*. It is essential that a free passage should be made under the constriction into the gut above, but if possible without detaching or loosening adhesions at the neck of the sac, whereby peritoneal infection is prevented. The introduction of the finger up the bowel may be followed by a free flow of fæces; but if not, then the constriction may be dilated from inside the bowel by dressing-forceps and a large drainage-tube introduced; or the constriction at the neck may be carefully divided from outside, and either a Paul's tube or a large drainage-tube inserted. Of course one should cut away as much of the stinking gut as practicable. An artificial anus is thus formed, through which for a time the patient can discharge the intestinal contents, and unless this desideratum is at once attained, failure is very likely to follow the operation. The wound is left open and a suitable dressing applied, into which the fæces can be received; possibly the best application is a layer of protective with a sufficient hole in the centre to allow the fæces to pass, and then over it a thick layer of tenax.

The relative value of the two methods cannot be fairly measured by statistics, since so many of the cases treated by the formation of an artificial anus are hopeless from the beginning. There can be no question that, with our present methods of intestinal suture, a large measure of success may be expected from the adoption of primary resection in the majority of cases.

Having thus dealt with the hernial contents, it is always advisable to perform a radical cure in uncomplicated cases, so as to prevent any recurrence of the condition. This is undertaken according to the methods already described, and the external wound subsequently closed and drained.

The **After-Treatment** in cases of strangulated hernia is of the greatest importance. The patient is placed in bed, and absolute quiet is maintained, no food being allowed for twenty-four hours, although a little ice may be sucked or hot water sipped in order to relieve thirst. If there is no pain, opium need not be administered, as it helps to maintain the paralyzed condition of the bowel; severe pain may, however, call for the hypodermic injection of a small dose of heroin. Liquid food can usually be taken at the end of twenty-four hours, and, if the patient's condition remains satisfactory, it is unnecessary to administer any purgative, the bowels often acting naturally; if they remain unrelieved for five or six days, a dose of castor oil should be given.

Various **Complications** may arise after the operation, needing special notice. (1) *Vomiting* may persist for a time as a result of the anæsthetic. It loses, however, its fæculent character, and may generally be stopped by washing out the stomach or by the hypodermic injection of morphia. (2) The *Paralytic* condition of the gut may remain for some considerable time, causing prolonged constipation. If there is no evidence of inflammatory mischief, it is best treated by the administration of a purgative or by a turpentine enema. (3) *Acute Enteritis* may arise either in the portion of strangulated gut or just above. This is usually indicated by localized pain and perhaps the passage of mucus, which may be so abundant as to amount to diarrhœa; the vomiting, moreover, persists, but is no longer stercoraceous. It is best treated by the administration of bismuth combined with chlorodyne, whilst all solid food is interdicted. (4) It is possible that, although the gut looked healthy at the time of operation, its walls were in reality already infected, and in spite of the relief of the constriction, *infective gangrene* may follow, causing death from peritonitis. (5) Occasionally acute septic peritonitis results from a localized perforation, either of a small gangrenous patch or from ulceration along the 'constriction groove.' *Treatment.*—The condition is obviously one of the gravest import, and must be dealt with actively if the patient is to be saved. The abdomen must be opened, the affected coil identified, and if need be resected, or fixed in the wound and opened for drainage purposes. The peritoneal cavity itself is dealt with according to the rules already given. (6) *Localized Peritonitis* may be looked on as a conservative measure, whereby Nature isolates some focus of danger from the general peritoneal cavity. Occasionally localized suppuration follows as the result of a limited ulceration or perforation of the gut; the pus must then be let out at the earliest possible moment, but a fæcal fistula is very likely to follow.

It is impossible to describe in detail every form of strangulated hernia. A few facts, however, must be stated about the more important varieties. In **Strangulated Inguinal Hernia** the constriction most commonly occurs at the neck of the sac, usually close to the external abdominal ring, as a result of the condensation of the surrounding tissues. The signs are generally very characteristic, and the condition can rarely be mistaken. Some difficulty may be experienced in distinguishing it from *inflammation of an undescended testis ;* in this, however, there is no persistent vomiting or constipation, whilst the absence of the testis below, and the existence of the peculiar testicular sensation, when the swelling in the canal is compressed, should clear up the case. Occasionally the two conditions co-exist, and then a correct diagnosis, apart from an open exploration, may be almost impossible. *Torsion of the testis,* and subsequent strangulation of the organ, give rise to a swelling not at all unlike a strangulated hernia, but the absence of constipation and fæcal vomiting should prevent mistakes.

Division of the stricture in the course of the operation is performed in a vertical direction, the surgeon cutting directly upwards, the reason being that it is impossible in old-standing cases to be certain whether the hernia is oblique or direct, and thus the liability to injury of the epigastric artery is diminished. If, however, the modern method of operation is followed, and the external oblique aponeurosis exposed and freely divided, it will often be found that the constriction is relieved by this means alone, and reduction becomes possible. The sac, however, should always be opened, and the condition of the bowel examined.

In **Strangulated Femoral Hernia** it is more common to find bowel than omentum, and it is in this situation that partial herniæ (Richter's) are most frequently met with. A tense painful swelling is felt, situated in the neighbourhood of the saphenous opening, and the diagnosis from inflamed lymphatic glands and phlebitis of a varicose saphena vein may not be altogether easy, particularly if omentum alone is present. The history of the case, and a careful consideration of the physical signs and symptoms, should generally be sufficient to clear up the diagnosis. The constriction is usually met with opposite Gimbernat's ligament, and to divide it the surgeon must cut directly inwards, so as to incise that structure. The plan already mentioned of nicking it in two or three places, rather than freely dividing it, is especially useful in this situation, on account of the occasional abnormal course of the obturator artery, which is stated to be wounded once in every 150 cases. The accident would be recognised by the occurrence of free hæmorrhage after the use of the hernia knife. In such a case, the rupture is first reduced, the wound enlarged upwards, and both ends of the divided vessel secured, if possible; failing this, carefully adjusted pressure may be employed. Where the constriction is very tight, so that it is almost impossible to pass a director between Gimbernat's ligament and the intestine, the plan already mentioned of dividing the constriction from without may be utilized with advantage.

Gangrene is more than twice as common in femoral hernia as in inguinal (19·5 per cent. in femoral against 6·1 per cent. in inguinal). Where enterectomy is feasible, it will often be necessary to open the abdomen by an additional incision above the pelvic brim, and then, having divided the constriction at the neck of the sac, the affected coil must be slipped back and pulled out of the upper wound, the greatest care being taken not to contaminate other coils of intestine. The shortness of the mesentery renders it impossible to perform the necessary manipulations through the wound in the groin.

It is quite possible to overlook the existence of a small Richter's hernia, and only to ascertain its presence during a laparotomy for an acute attack of obstruction. Under these circumstances the greatest gentleness must be exercised in any attempts to withdraw the bowel from the sac, for fear of tearing the gut and flooding the peritoneal cavity with fluid fæces. It is usually well to cut down on the hernia from outside, open the sac, and divide the constriction; and then partly from without, partly from within, to reduce the strangled portion of bowel, which is brought to the surface and carefully examined. In many such cases drainage of the gut by a Paul's tube will be required, and a subsequent enterectomy.

Sequelæ of Strangulated Hernia.—(1) **Artificial Anus** may arise from the sloughing of the intestine and overlying skin apart from operation; or from the surgeon's interference, either by his opening the gut in mistake for the sac, or by his incising it when gangrenous; or it may slough subsequently, if left *in situ* when gangrene is threatening. After a time the surrounding parts settle down and heal over, the diversion of the fæces from their natural course becoming more and more complete, owing to the formation of a *spur* of mucous membrane, which lies across and blocks the entrance to the lower portion of the bowel. This spur arises partly as a result of the kinking of the gut, partly from the intra-abdominal pressure, which pushes the exposed inner wall of the intestine forwards. The effects produced by an artificial anus on the individual vary with the portion of the bowel involved. If the jejunum or upper part of the ileum is thus opened, the patient soon loses ground and becomes emaciated, owing to the escape of the intestinal contents before the nutritive elements of the food have been absorbed. Eczema of the skin in the neighbourhood is usually produced, resulting from the irritation of the fæces. For treatment, see p. 1036.

(2) **Fæcal Fistula** occasionally results from a strangulated hernia, owing to a perforative inflammation of the gut after the relief of strangulation, whether at the site of constriction, or above or below it, in the latter case arising from a stercoral ulcer. Though the lesion may be intraperitoneal, it by no means follows that general peritonitis need result, since sufficient plastic material may be formed around it to shut off the general peritoneal cavity, and to allow the extravasated contents of the bowel to find their way outwards through a sinuous track to the external wound. It may be some days before any evidence of the existence of this condition appears. Not uncommonly the opening will close naturally as a result of cicatricial contraction, and hence no steps need be taken to deal with it until all hopes of such a result have faded. Where, however, it persists, attempts may be made to effect this purpose by injecting stimulating lotions, or by applying the actual cautery to the interior of the fistula; but more frequently an operation to expose, if practicable, the wound in the gut, and to close it by suture, or to remove the affected segment, will be necessary.

(3) **Stenosis** of the gut at the site of strangulation may ensue, giving rise to the symptoms already indicated (p. 1022), which may appear weeks or months later.

CHAPTER XXXVII.

INTESTINAL OBSTRUCTION.

By **Intestinal Obstruction,*** or **Ileus,** is meant a condition in which the onward passage of fæces is prevented. It is often associated with vascular phenomena, due to strangulation or kinking of the gut, which result in a deficient supply of arterial blood reaching the part, thereby predisposing to gangrene.

Various elements enter into the picture provided by a classical case of obstruction, and of these the most marked are:

1. **Coprostasis,** or retention of fæces. The fact that simple constipation may last for a week or more at a time, and do no harm to the patient beyond a certain slight degree of toxic poisoning, demonstrates that this is not the only element in cases of obstruction, and indeed is often an almost insignificant factor in acute cases. Yet it colours the whole picture, and has very marked results in the clinical manifestations. Retention of the intestinal contents is certain to be followed by their decomposition and liquefaction, and this causes the intestinal canal to be filled with a quantity of offensive fluid material, partly due to bacterial activity, partly to the pouring out of a considerable quantity of secretion from the congested gut wall. If the obstruction is only partial, this liquefaction of the bowel contents may enable them to pass on, and the patient's attack of partial obstruction is followed by one of diarrhœa, whereby relief is obtained. If the obstruction, however, is complete, the intestine above the block is gradually filled with this decomposing material, from which toxins may be absorbed, the patient being thereby poisoned.

A second result of this decomposition of the retained fæces is the development of gas, which may be so marked as to lead to great abdominal distension, or *meteorism*. Whilst present in almost every case to a certain degree, it is most marked when there is considerable involvement of the mesentery, and experiments on animals indicate that constriction of the nerves contained therein is the chief factor in its production.

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* For much of the material incorporated in this chapter we beg to acknowledge our indebtedness to Sir Frederick Treves' classical text-book on the subject (published by Cassell and Co.), than which nothing better has appeared, and which we have freely utilized.

2. **Increased peristalsis,** with the object of forcing the intestinal contents past the block, is often an important feature in the case, leading to severe pain of a colicky character. So violent may these efforts become that the bowel, weakened by distension and inflammation, is finally torn, and perforative peritonitis rapidly ends the case.

3. **Regurgitant vomiting** is always a prominent element. At first the gastric contents alone are ejected, but later the vomit becomes bilious, and even stercoraceous or fæcal. The origin of this phenomenon is still a little dubious. Some have considered it due to antiperistalsis; others maintain that the ordinary onward movements of the bowel are quite sufficient to explain it. The intestinal contents are urged forward against the face of the obstruction, and, being unable to pass, an axial regurgitant stream is produced. It is a little difficult to see how this could occur when the lower end of the colon is the part affected. Whatever the mechanical explanation, there is no question as to the influence of the nervous system in its production, or as to its being chiefly reflex in character, which is evident from the fact that it occurs whether omentum or bowel is strangled. Hence, it is easy to understand that it commences early in children and sensitive women, on account of the greater irritability of their nervous centres, whilst it is also more marked when the small intestine is involved. Anything that increases peristalsis naturally intensifies its occurrence.

4. **Nervous phenomena** also add their peculiar features to the picture. The affected coil of bowel is directly paralyzed by the lesion, but, in addition, various reflex manifestations occur. Thus, in acute cases the patient suffers almost at once from shock, which passes off after a time, and from collapse due to toxæmia at a later date; vomiting and perhaps hiccough develop reflexly, and the latter sign is always to be looked on with grave suspicion and as an omen of bad import. In the latest stages intestinal paralysis from the onset of peritonitis may dominate the scene.

5. **Infective phenomena** are likely to follow sooner or later, the bowel walls being attacked by the virulent organisms contained within them. Complete paralysis and want of blood-supply predispose them to bacterial invasion, and hence the more acute forms of infective gangrene are chiefly seen in conditions of the strangulation type; when mere obstruction is present without vascular changes, microbic invasion rarely produces more than a patchy necrosis, or, more commonly, perforative ulceration. Of course, when infective gangrene is present, virulent toxins develop in the walls of the gut, and a rapid depreciation of the patient's general condition follows from their absorption.

6. Finally, **death** is almost certain to ensue apart from surgical assistance, although a few cases may recover spontaneously. The final event is due either to perforative peritonitis, or to simple exhaustion, the result of toxic absorption from the retained fæces or from the necrotic intestinal wall, of constant pain and vomiting, want of nutrition, and general dehydration of the tissues.

Causes.—Much elaborate work has been undertaken to produce a satisfactory classification of the many diverse causes of intestinal obstruction; and when one mentions the fact that a recent attempt included eighty distinct causative lesions, it is obvious that there is an abundant field for this type of ingenuity. It must suffice here to state that there are two great divisions—the dynamic and the mechanical.

(1) **Dynamic** ileus is due to some paralytic or spasmodic condition of the intestinal wall, which results in interference with its power of transmitting onwards its contents. *Paralysis* of the bowel results from: (*a*) Diffuse or localized acute infective inflammation, as in septic peritonitis or acute appendicitis; (*b*) torsion of intra-abdominal viscera, such as the spleen or omentum, or of tumours—*e.g.*, ovarian cysts, leading to the so-called 'aseptic' peritonitis; (*c*) embolus or thrombosis of the mesenteric vessels, leading to necrosis; (*d*) nervous lesions, which may involve the spinal cord itself, or more frequently the peripheral nerves—*e.g.*, a tumour at the root of the mesentery. *Spasm* of the gut, as by chronic lead-poisoning, may also determine obstructive phenomena.

(2) **Mechanical** ileus is the variety most commonly seen. (*a*) The gut may be *strangled* by bands or through apertures, causing internal strangulation. (*b*) It may be *kinked* over bands, thereby determining not only occlusion of the lumen, but also a marked interference with the vascular supply. (*c*) The intestine may be *twisted* on its own axis, giving rise to a condition known as volvulus. (*d*) One portion of the bowel may be *invaginated* into a neighbouring portion, constituting an intussusception. (*e*) The lumen of the bowel may be *blocked* by foreign bodies or accumulations of fæces (obturation). (*f*) The onward passages of the fæces may be rendered difficult or impossible by the gut becoming *narrowed*, as from cicatricial or cancerous stenosis, or the pressure of external tumours.

The most useful division is, however, the clinical, grouping together those cases which present a similarity of symptoms; and this method will be employed here, the subject being discussed under the three headings—Acute Obstruction, Chronic Obstruction, and Intussusception.

Acute Intestinal Obstruction.

The following are the chief **Causes** which give rise to this condition:

1. Strangulation by bands or adhesions, or through apertures, etc.
2. Volvulus.
3. The impaction of foreign bodies.
4. Strangulation over a band or acute kinking of the gut, both very rare conditions.
5. Acute intussusception.
6. It may be the termination of a chronic obstruction.
7. Acute localized paralysis of the gut due to an infective inflammation—*e.g.*, acute suppurative appendicitis.
8. Acute enterospasm.

It will be noted that in the first five of these causes, where the ileus is primary, there is a definite vascular lesion in addition to the obstruction, which threatens the patient at an early date with perforative ulceration or gangrene, and it is mainly on the presence of this element that the acuteness of the case depends.

The **General Symptoms** of acute obstruction are practically identical with those of a strangulated hernia. The patient is suddenly seized with severe abdominal pain somewhat of the nature of colic, and perhaps referred to the umbilicus, coming on sometimes during some special effort—*e.g.*, lifting a heavy weight, or sometimes when lying quietly in bed. At the same time he suffers from shock, as evidenced by a weak pulse, pale face, and cold, clammy sweat, the temperature of the body falling below the normal. The shock is usually more or less recovered from, but the pain persists, and is liable to exacerbation and intermissions, soon becoming continuous. Vomiting ensues, being at first limited to the contents of the stomach, but quickly changes to a bilious, stercoraceous, or even fæcal character. Distension of the abdomen is generally present, but its amount and characters vary with the site of the lesion. Signs of constitutional depression and exhaustion follow in a short time, the pulse becoming weak, rapid, and thready, the temperature remaining subnormal (except occasionally after the supervention of peritonitis, when it may rise a few degrees), the face looking drawn (*facies Hippocratica*), and the abdomen being distended and painful. Finally, if unrelieved by treatment, the patient dies, and usually

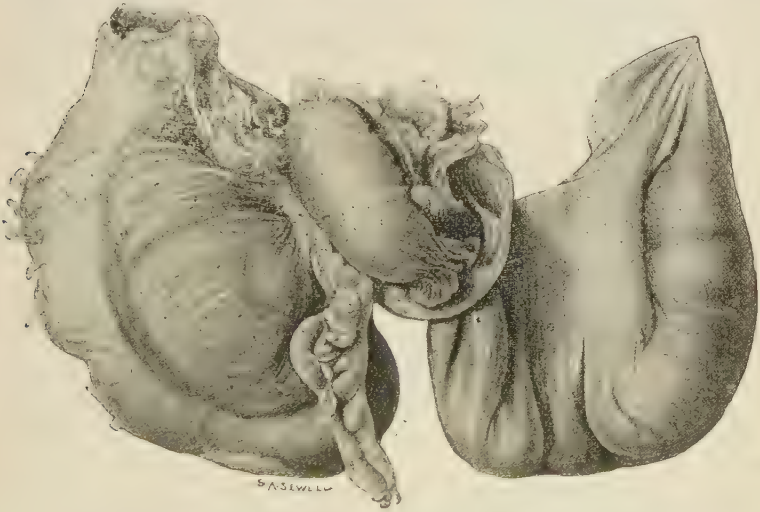

FIG. 520.—STRANGULATION OF A COIL OF THE LOWER END OF THE ILEUM BY A BAND DEVELOPED IN THE NEIGHBOURHOOD OF THE VERMIFORM APPENDIX. (KING'S COLLEGE HOSPITAL MUSEUM.)

within seven to ten days from the onset, owing to exhaustion or perforative peritonitis. Constipation may be absolute from the first, not even flatus being passed, but at any time the lower bowel may empty itself, and raise false hopes as to the prognosis.

The Special Forms of Acute Obstruction must now be considered *seriatim.*

1. **Strangulation by Bands or Adhesions, through Apertures, etc.—Causes.**—(*a*) *Isolated peritoneal bands and adhesions* are usually the result of old plastic peritonitis of a localized and chronic character. The greatest variety is met with in the appearance and situation of these adhesions; most frequently they are single and cord-like; sometimes they are broad and membranous, constituting a false ligament; or, again, they may be multiple. A common situation is between different parts of the mesentery, or between the mesentery and some other viscus, the cause being either disease of that viscus (usually a pelvic organ, the cæcum, or the appendix), or inflammation of a mesenteric gland with localized peritonitis. Whatever the exact cause, the mischief is most frequently found either in the right iliac fossa or in the pelvis. Two methods of producing strangulation exist: either the bowel passes under the arch or loop formed by a short constricting band, and cannot return (Fig. 520); or, if the band is long, it may form a loop or noose through which the bowel passes, and so becomes strangled (Fig. 521). (*b*) *Cords formed by the omentum* result from union between its fimbriated extremities and some part of the viscera or parietes, forming at first a broad band-like adhesion, which is gradually moulded into a rounded cord by the constant dragging and pulling to which it is subjected. They are usually coarser and thicker than those due to peritonitis. The mechanism of strangulation is identical, the noose form being perhaps the more common, since the adhesions are likely to be longer. (*c*) *Meckel's diverticulum* (p. 1014) is liable to cause strangulation when its free end becomes adherent either to the parietes or to the viscera; it is attached most frequently to the mesentery of the ileum, and after that to the neighbourhood of the umbilicus. Occasionally the diverticulum ends in a fibrous cord, which may remain fixed to the umbilicus, or floats free in the abdominal cavity, and subsequently becomes adherent to some other structure, thus producing a fibrous cord. Strangulation may be effected by bowel passing under the loop formed by the adherent diverticulum. (*d*) The *vermiform appendix, appendices epiploicæ,* or *Fallopian tubes* may contract abnormal attachments, and thus form arches or loops under which bowel may pass and become strangled. (*e*) *Slits, pouches, and apertures* in the peritoneal investment, whether normal or abnormal,

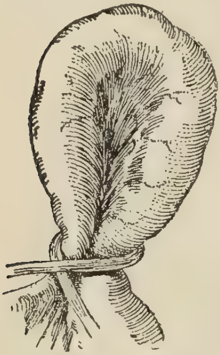

FIG. 521.—STRANGULATION BY BAND.

may lead to strangulation. All external herniæ may be grouped under this heading, as also those conditions known as internal hernia, in which the abdominal contents find their way into pouches in the posterior wall of the peritoneum—*e.g.*, into the lesser sac of the omentum, the fossa duodeno-jejunalis, or into some of the retro-cæcal fossæ. Slits may also be found in the omentum or mesentery, either congenital, traumatic, or the result of operations.

Phenomena.—This form of obstruction usually occurs in young people, and is rare after forty; it constitutes more than a fourth of all the forms of internal obstruction, and the lower 2 feet of the ileum are most frequently involved. There may be a previous history of peritonitis, but that may have been overlooked or forgotten; the onset is usually sudden, and the symptoms of strangulation, as detailed above, are of a typical character. The abdomen is flaccid at first, and not tender until peritonitis ensues, on about the third or fourth day. There is generally no obvious tumour, and no peristalsis or dilated coils of intestine are to be seen. Occasionally an area of localized fulness or of fixed and limited tenderness may indicate the site of the lesion. The average duration is about five to seven days, the patients dying of exhaustion or toxæmia following peritonitis.

2. **Volvulus** is the most common cause of acute primary obstruction of the large intestine. By it is meant a rotation of the gut upon its own mesenteric axis in such a way as to interfere not only with the passage of the intestinal contents, but also sooner or later with the circulation, determining a condition of strangulation. Occasionally a similar result is brought about by the intertwining of one coil, usually of small intestine, with another. The sigmoid flexure is the part generally affected, although it occurs in the cæcum when there is a definite meso-cæcum, or in the small intestine. In the former situation it is predisposed to by a long narrow sigmoid meso-colon, so that the two ends of the loop are brought closely together; this condition may be of congenital origin, but is usually due to the traction induced by prolonged chronic constipation; a distended sigmoid hanging into the pelvic cavity drags upon and elongates the meso-colon, tending to approximate the two ends of the loop, and necessarily causing a slight obstruction at these spots. Some irregular movement of the gut or of the abdominal walls suffices to cause rotation of the pedicle, and thus brings about the volvulus. When once present, plastic peritonitis soon fixes the coil, whilst the pressure on the vessels causes venous congestion and such obstruction to the arterial supply of the gut as almost certainly to end in its death. Distension of the coil with gas from decomposition of the retained fæces also aggravates the condition.

Symptoms.—Volvulus is rare before the age of forty, and apparently occurs more often in the male sex. A history of chronic constipation precedes it, but the acute symptoms start abruptly. Pain is always present, at first intermittent, but finally constant, and there is usually tenderness over the sigmoid flexure. The pain, vomiting, and collapse are not so severe or marked as in other forms of strangulation, but abdominal distension from excessive flatus, and resulting dyspnœa and thoracic embarrassment, are very distressing. Tenesmus is occasionally present. A localized peritonitis is usually developed, but sometimes it becomes diffuse. Natural cure is unknown, the patient dying either in five or six days from collapse and interference with respiration, or at a somewhat later date from peritonitis.

3. **Impacted Foreign Bodies,** which may cause intestinal obstruction, are of three types: gall-stones, foreign bodies that have been swallowed, or intestinal concretions (enteroliths). The general facts connected with their presence in the intestine have been already noted (p. 1019).

Gall-stones only cause obstruction when of large size, and then usually gain entrance to the intestine by ulceration from the gall-bladder into the duodenum. The usual site of impaction is in the lower ileum. Women over fifty are most often the subjects of this condition, and there may be merely a history of some inflammatory lesion in the region of the gall-bladder, and none of biliary colic. Such patients frequently suffer from intermittent subacute attacks of incomplete obstruction, which, though severe for a time, are relieved by purgatives. If the gall-stone is not passed, a final acute attack supervenes, which begins suddenly with pain and slight collapse, followed by vomiting, which is constant and copious, and in twenty-four to thirty-six hours becomes fæcal. The obstruction is often incomplete, flatus and even fæces being occasionally passed. The abdomen is soft and flaccid, and the affected coil and the gall-stone are rarely to be felt. Necessarily the symptoms vary with the site of impaction, usually becoming more urgent as the duodenum is approached. Death results from peritonitis or exhaustion.

Similarly, *enteroliths* are usually impacted near the cæcum, and if causing acute obstruction the symptoms are similar to those produced by a large gall-stone, being preceded by chronic attacks and severe colicky pain. In thin persons their presence may be detected by palpation of the abdomen.

4. Acute obstruction ensues when a coil of intestine lodges across a tightly-drawn adhesion, the lumen at each end being thereby entirely occluded, and the circulation arrested. The usual acute symptoms follow, which may, however, be relieved spontaneously. Sudden kinking of the gut may lead to the same result, being due to the contraction of fibrous adhesions or the dragging of diverticula.

5. For **Acute Intussusception,** see p. 1138.

6. When acute symptoms are developed at the termination of a case of chronic obstruction, the pain which had been intermittent becomes constant, the vomiting more violent and fæcal in character, and the fatal termination is due to acute peritonitis, or to exhaustion and toxæmia. Absolute constipation is always present, and the abdomen much distended.

7. True obstruction is sometimes associated with acute localized

enteritis or peritonitis, such as is seen in appendicitis, when the intestinal walls are paralyzed. This symptom is sometimes very marked, and even fæcal vomiting may occur, but by careful attention to the history and general condition of the patient a correct diagnosis should be reached. We append a table illustrating the chief diagnostic points between acute strangulation and acute appendicitis associated with peritonitis, one of the commonest causes of dynamic ileus:

	ACUTE INTERNAL STRANGULATION.	ACUTE APPENDICITIS WITH PERITONITIS.
Onset - -	Abrupt.	May be preceded by local pain.
Rigor - -	Absent.	Often present.
Temperature	Subnormal at first, rising at onset of peritonitis.	High at first, falling later from exhaustion or toxæmia.
Pain - -	Severe; referred to the umbilicus.	Severe; usually referred to the right iliac fossa.
Tenderness -	Absent till peritonitis comes on.	Present over cæcum even in early stages, and gradually spreading.
Vomiting -	Early, marked, and soon fæcal.	Less urgent, and seldom fæcal, except as a late symptom.
Abdominal parietes	Flaccid till peritonitis is present.	Tense and rigid from the first.

In most forms of dynamic ileus the obstructive phenomena are usually secondary to some peritonitic trouble, or to some intra-abdominal lesion which produces its own symptoms first, and then obstructive phenomena only as a secondary result of inflammatory paralysis. Thus in torsion of the pedicle of an ovarian cyst, the patient first complains of pain, and the tumour becomes large and tender. Should it be neglected, aseptic peritonitis ensues; after a variable period intestinal paralysis follows, and obstructive symptoms of a distressing type are produced, which will probably prove fatal, even if the cause is removed.

8. *Enterospasm* is the name applied to a functional disorder occurring in patients of a neurotic type, in which one or more sections of the intestinal canal undergo purposeless tetanic contraction. The colon is more commonly affected than the small bowel, and especially the cæcal and sigmoid sections. In the acute form the symptoms of urgent obstruction may be produced, and even peritonitis simulated; but more frequently the attacks are chronic, and persistent constipation results. Sometimes the appendix is tender, and has been removed for this affection without benefit. Antispasmodics of the belladonna type are required, and purgatives do but little good.

For **diagnosis and method of examination** of cases of acute obstruction, see p. 1140.

The **Treatment** of acute obstruction is practically included in one word—**Laparotomy.** The condition of the gut is in most cases identical with that found in a strangulated hernia, and although a few patients may recover by palliative measures—*e.g.*, enemata, opium, ice, etc.—yet the majority would be gravely injured by the delay caused by their employment. The danger of laparotomy increases directly with delay; hence, the sooner it is undertaken, the better for the patient. Whilst preparations for the operation are being made, an enema may be administered to clear the lower bowel, ice being given to suck, and a small dose of opium to relieve urgent pain. Two main objects must always be striven after in the operative treatment of such cases—viz., (*a*) to empty the distended bowel, and (*b*) to remove the cause of the obstruction. The second of these requisites is always most desirable, but unless at the same time the putrid contents of the upper portion of the intestine are removed, little real good has been accomplished, since the patient is being slowly poisoned by toxic absorption. The late Mr. Greig Smith declared most emphatically that 'no operation for intestinal obstruction is complete if the patient leaves the operating-table with a greatly distended abdomen.' Hence, in many cases it is desirable to deal with the engorged bowel first by establishing an artificial anus, and to leave the search for the obstructing body till a later date. A very high death-rate must always be expected in these cases, but statistics prove that, in cases where the cause of the obstruction is not at once obvious, primary enterostomy, if followed by a satisfactory discharge of the intestinal contents, gives results in many instances equal to, or even better than, treatment directed towards the cause of the trouble.

In the *most urgent cases*, where the patient's abdomen is acutely distended, and fæcal vomiting has been present for some time, it is not advisable to administer a general anæsthetic: if such is attempted, the patient's life is often lost from stoppage of the respiration, precipitated possibly by a severe attack of fæcal vomiting. Local anæsthesia by Schleich's method of infiltration must be relied on, or spinal analgesia, and a small incision made through the linea alba below the umbilicus; the first presenting coil of intestine is withdrawn, and after protecting the peritoneal cavity with gauze or swabs, is tapped with a large trocar and cannula so as to allow the first gush of flatus and fæces to be carried away from the wound. The opening is then enlarged sufficiently to allow a rubber or Paul's tube to be introduced and tied in, and whilst the bowel is emptying itself, it is fixed by stitches to the abdominal wall. The stomach should always be thoroughly washed out with warm water before or during the operation.

In *less severe cases*, the stomach should be washed out as a preliminary measure before administering the anæsthetic. The head must not be placed on a lower level than the stomach, for fear of fluid regurgitating along the œsophagus and choking the patient; several deaths from this cause have been reported. The abdomen is then opened in the middle line below the umbilicus, and a definite search made for the cause of the obstruction if it is not at once obvious. The hand is first passed to the hernial regions, and then to the right iliac fossa, so that the cæcum may be examined. If this is distended, the cause necessarily lies below it; if collapsed, above it. In the former case, the condition of the sigmoid flexure should next be investigated, and finally, if this viscus is collapsed, the hand should be run along the colon, special attention being directed to the splenic flexure. If the cæcum is collapsed, perhaps the best method to adopt is gently to withdraw from the abdomen successive portions of gut, about a foot at a time. These are carefully examined, and replaced by the assistant whilst the next portion is being withdrawn. The remainder of the intestines during this process are protected and kept back by the application of hot sterilized abdominal cloths. The cause of the obstruction is in this way sooner or later discovered, and may be dealt with according to circumstances. If the intestines are too distended to allow of such manipulation, it may be advisable to open or tap one or more of the dilated coils, and thus reduce the distension before proceeding with any methodical search for the obstruction. For this purpose a small trocar and cannula is inserted through the anti-mesenteric border; the flatus and fæces are allowed to escape; and the puncture is subsequently buried by a purse-string suture. It is sometimes necessary to perform this in two or three different situations.

Omental bands or peritoneal adhesions should be divided between ligatures. The vermiform appendix may be removed, or a Meckel's diverticulum excised. A volvulus should be untwisted, if possible; but this is usually impracticable, owing to peritoneal adhesions, and in such cases it is advisable to withdraw the coil from the abdomen, and if the large intestine is involved, an artificial anus should be made. Foreign bodies are, if possible, displaced forwards or backwards to a more healthy portion of the bowel, and then removed by a longitudinal incision along the anti-mesenteric border, the wound being subsequently closed by a row of Lembert's sutures. Of course volvulus of the small intestine or gangrene of the gut, if present, may necessitate an enterectomy, but it must always be kept in view that the essential feature of the operation is drainage of the intestine, and therefore the establishment of an artificial anus as a temporary measure is often desirable; re-union can be effected when the gut has emptied itself.

Chronic Intestinal Obstruction.

The **Causes** of chronic obstruction are very numerous, and, looked at from an anatomical standpoint, may be divided into the following groups:

1. Intra-intestinal conditions—*e.g.*, impaction of fæces, foreign bodies, etc.

2. Affections of the intestinal wall, such as stricture, new growths, especially those of a cancerous type, adhesions or matting together of

coils of intestine, contraction or kinking of the gut from mesenteric gland disease, etc.

3. Compression of the bowel by tumours, cicatricial bands, etc., developing outside the intestine.

Fæcal impaction and the development of a cancerous growth are far and away the commonest causes of chronic obstruction.

The **General Symptoms** of chronic obstruction are more or less as follows: The patient suffers from gradually increasing constipation, alternating occasionally with watery diarrhœa, spurious in nature, and set up partly by a catarrhal enteritis due to the irritation of retained fæces, partly by decomposition of the fæcal material. At irregular intervals more severe symptoms arise, consisting of pain, colic, vomiting, and absolute constipation, owing to some temporary complete obstruction, as by the impaction of a mass of undigested food or fæces, assisted perhaps by a valve-like fold of mucous membrane across the passage. The abdomen becomes distended, and coils of gut may be seen in a condition of active peristalsis. These attacks usually pass off after a time, a copious evacuation of the bowels taking place, either naturally or after the administration of a purgative. Finally, one of these seizures persists and destroys the patient, either by exhaustion or by perforation followed by peritonitis, unless suitable treatment is promptly adopted. The vomiting is never such a marked feature as in acute obstruction, until the final stage, when it becomes fæcal. The abdomen is always more or less distended and tympanitic, and its contour varies with the site of the obstruction; if this is situated above the ileo-cæcal valve, the swelling is mainly central, whilst if in the rectum or lower portion of the colon, it is most marked in the flanks. Distended coils of intestine can be plainly seen through the abdominal walls in thin subjects, as also evident peristalsis. When arising from simple stricture, no tumour is to be felt; but if due to malignant disease, and if the abdomen is not very distended, the growth may possibly be detected.

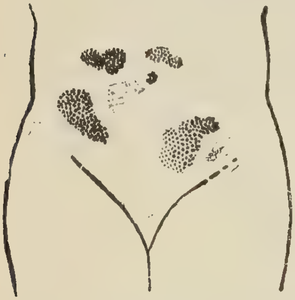

Fig. 522.—Diagram to indicate the Usual Sites of Fæcal Impaction — viz., the Cæcum, Transverse Colon, and Sigmoid.

Fæcal Impaction occurs in adult females who have previously suffered from chronic constipation. The cæcum and sigmoid flexure are the most common seats of obstruction, but the transverse colon is not unfrequently affected (Fig. 522). A doughy tumour may often be felt at one of these spots, which can in some cases be indented with the fingers, whilst in others it may be of stony hardness. The surface of the mass is usually more or less nodulated, and the intestine tender from the accompanying inflammation. The temperature is often raised, from toxic absorption through the intestinal wall, and there may even be a rigor. The acute symptoms are always preceded by a prolonged period of malaise and ill-health, the appetite being defective, the breath offensive, and the tongue foul. On rectal examination the presence of scybala may often be detected.

The special symptoms arising from the other conditions which give rise to chronic obstruction, such as stenosis of the bowel, have been already referred to.

The **Diagnosis** of chronic obstruction is obvious, but it is often by no means easy to ascertain the exact cause of the trouble. A thorough investigation of the case, according to the plan given hereafter, must be undertaken, and by this means some conclusion may be arrived at as to the nature and seat of the obstruction.

The **Treatment** of chronic obstruction is always a matter of difficulty and anxiety, owing to the uncertainty often felt as to the diagnosis. It ought to be possible, however, to decide whether the block is located in the large or small intestine, since the character of the abdominal distension and the symptoms are tolerably distinctive in the two forms.

If the case is not of the most urgent type, the patient is put to bed, the diet restricted to fluids, and belladonna, combined with small doses of calomel, administered. At the same time copious enemata should be given two or three times daily, and preferably in the genu-pectoral position, or lying on the right side with the pelvis well raised. Purgatives are studiously avoided, as also opium; probably the patient has taken plenty of the former before coming under observation, whilst the latter, although it may check vomiting and relieve pain, is certain to mask symptoms, and thus prevent the true course of the disease from being watched. Should the symptoms be urgent from the commencement, or the treatment suggested fail, the question of operation has to be faced. If the obstruction is located in the small intestine, a laparotomy must be undertaken, using the same precautions as in acute cases. If the cause of the trouble is easily found, a coil situated just above is withdrawn from the abdomen, opened, and a Paul's tube tied in so as to allow retained fæcal material to escape. It is wiser not to deal with the local trouble (unless strangulation is present) until the urgent symptoms have disappeared. If, however, the patient's condition is serious, and the site of obstruction cannot be readily found, any distended coil may be withdrawn and opened. The practice of allowing numerous coils of intestine to escape in order to facilitate the exploration of the abdomen is not to be recommended.

When the cause of the obstruction is located in the large intestine, colostomy is usually required. The lumbar operation may possibly be undertaken; but the majority of surgeons at the present time prefer the iliac proceeding. If the rectum or sigmoid flexure is clearly the seat of the trouble, the usual incision on the left side can be made; but if there is no indication as to the part of the colon involved, a median laparotomy is perhaps preferable, a distended portion of the gut being withdrawn and tapped, and a Paul's tube tied in.

In chronic peritonitis, where the intestines are hopelessly matted together, but little can be done beyond the administration of enemata, and possibly abdominal massage. The history of the case will generally suffice to suggest its nature, and operative treatment should then be avoided.

Fæcal impaction requires the regular and repeated administration of large enemata, given through a long tube, whilst belladonna and calomel may also be administered. Should hard scybala be lodged in the rectum, it may be necessary to break them up *in situ*, and remove them piecemeal.

Intussusception.

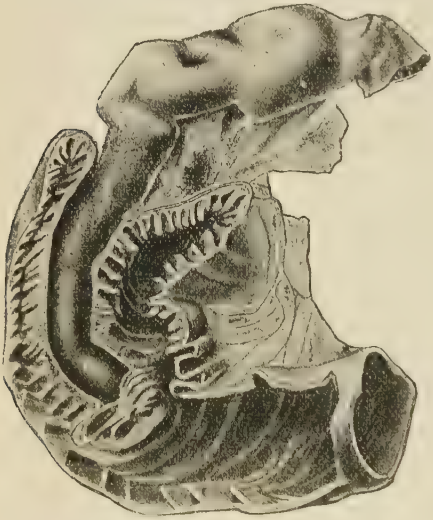

Fig. 523.—Intussusception. (From Specimen in College of Surgeons' Museum.)

By **Intussusception** is meant the protrusion or invagination of one part of the intestine into another, giving rise to the condition illustrated in Fig. 523. The constituent parts are seen more diagrammatically in Fig. 524. The upper portion is always prolapsed into the lower, except occasionally during the irregular peristalsis which takes place during the death-throes. The invaginated portion (*a*) is known as the *intussusceptum,* whilst the lower portion (*b*) into which it is protruded is known as the *intussuscipiens.* An intussusception, then, consists of three layers—the outer or *ensheathing* layer (i.), an inner or *entering* layer (iii.), and between the two the *returning* layer (ii.) Not only does the intestine enter, but with it a certain portion of the mesentery; and it is to the constriction of the vessels contained therein, and later on possibly to their complete obstruction, that the more serious phenomena are due—*e.g.*, gangrene, perforation, or rupture of the gut. In addition to this, actual obstruction to the passage of the intestinal contents may be brought about by the traction of the mesentery, which renders the orifice of the intussusceptum slit-like, by the swelling and congestion of the intestinal wall, or perhaps by the impaction of a portion of undigested food within the lumen of the gut. Peritonitis usually follows, being possibly due to the invasion of a portion of the damaged intestinal wall by the *B. coli* or other intestinal organisms. If limited in extent, it may merely lead to irreducibility of the intussusception, owing to adhesions forming between the serous coats of the entering and returning layers. In other cases, and especially when ulceration or gangrene is present, a diffuse peritonitis may be lighted up, and this may result in the death of the patient. The bowel above the site of invagination becomes dilated, and possibly stercoral ulcers may be formed, particularly in the more chronic cases.

The **Cause** of intussusception is generally stated to be irregular and violent peristalsis, however induced, whether by the presence of irritating ingesta, or by the existence of polypoid tumours, malignant growths (Fig. 485), or possibly worms; the presence of scybalous masses of fæces may also lead to its occurrence. In a few cases injury —*e.g.*, blows on the abdomen, or severe strains during jumping— have been held responsible for its onset, but very frequently no cause can be assigned.

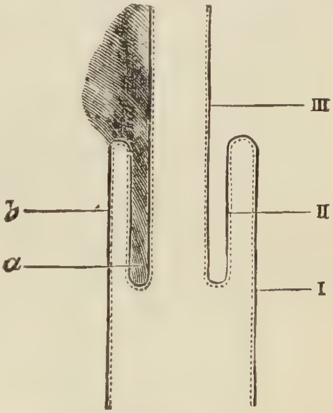

FIG. 524.—DIAGRAM OF INTUSSUSCEPTION.

a, Intussusceptum; *b*, intussuscipiens; I., ensheathing layer; II., returning layer; III., entering layer.

Intussusception is met with in four chief **situations:** (1) The *ileo-cæcal* variety is much the commonest, constituting 44 per cent. of all cases (Treves). In it the ileum is protruded into the colon, the apex of the intussusceptum being formed by the ileo-cæcal valve. Owing to the great mobility of the ileum, a considerable portion of gut may be thus invaginated, and a good many cases have been observed in which it has actually projected through the anus. (2) The *enteric* variety involving the small intestine comes next in order of frequency, being met with in 30 per cent. of the cases. It is most often seen in the lower jejunum, and is rarely of great size. (3) The *colic* form may occur at any part of the colon or rectum, and, owing to the fixity of this portion of the gut, is limited in extent. It is met with in about 18 per cent. of the cases. (4) The *ileo-colic* only occurs in 8 per cent.; in it the ileum is prolapsed through the ileo-cæcal valve, which for a time retains its normal position; but after the intussusception has attained a certain size, the valve and cæcum are also invaginated into the ascending colon. In each of these varieties, except the last, the intussusception grows at the expense of the external or ensheathing layer, the apex of the protrusion being always formed by the same portion of gut; but in the ileo-colic variety, as just stated, it increases by the passage of more and more of the ileum through the valve; after a time this stops, and is replaced by the ordinary form of growth.

Intussusception is occasionally met with as a *post-mortem* phenomenon, resulting from the irregular intestinal movements which occur during the death crisis. The condition is recognised as being of this nature by the absence of inflammatory signs, by the fact that it is sometimes due to a reverse peristalsis, and by more than one intussusception being present.

The **Clinical History** varies according to whether the condition is acute or chronic.

Acute Intussusception occurs most frequently in infants under two years, being the most common cause of obstruction at this age.* The onset is sudden, the child being attacked with severe pain, possibly localized and more or less paroxysmal at first, but rapidly becoming continuous and diffused over the abdomen. This is followed by vomiting, which, however, is less severe than in acute strangulation, and not so often fæculent. The patient rarely suffers from absolute constipation; but diarrhœa and the discharge of blood-stained mucus, perhaps associated with tenesmus, and often without fæces, are common. Collapse soon supervenes, and in the worst cases this may be so severe as to kill the patient within twenty-four hours; otherwise a fatal issue from exhaustion or peritonitis is reached within a week. On examining the abdomen, but little distension or tenderness is noted, unless acute peritonitis is present; in more than half the cases a distinct tumour can be felt, cylindrical in outline, and sometimes described as ' sausage-shaped,' following the course of the intussusception and generally curved, owing to the traction of the mesentery. In the ileo-cæcal variety it extends from the right iliac fossa across the brim of the pelvis to the left, the colon being dragged downwards. This may be associated with an absence of resistance in the right fossa, which feels empty, constituting what is known as the ' signe de Dance.' In other cases the tumour may be more limited, and distinctly moveable. The rectum should always be carefully examined, and preferably under an anæsthetic so as to permit a thorough bimanual examination of the rectum and abdomen to be made.

A natural cure occasionally follows, resulting either from spontaneous reduction, or from sloughing of the intussusceptum, whilst the peritoneal cavity is shut off by a circle of plastic lymph uniting the ensheathing and entering layers of the gut. When the latter takes place, the subsequent condition is not very satisfactory, owing to the formation of a fibrous stricture.

The association of intussusception with *Henoch's purpura* is an interesting phenomenon. This disease is characterized by a purpuric eruption, joint pains, vomiting, and intestinal colic, the latter probably due to hæmorrhage into or from the intestinal wall. There is no regularity in the evolution of the symptoms, and when the intestinal phenomena are early, the diagnosis from intussusception may be difficult. In not a few cases intussusception develops, its existence being suggested by the severity and persistence of the colic and perhaps by tenesmus and loss of blood *per anum*, and confirmed by the discovery of a tumour.

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* Out of 187 cases of intussusception, H. L. Barnard found 72 per cent. were under one year of age.

Chronic Intussusception occurs more frequently in adults than in children, the onset being gradual and the course varying widely in different cases. The patient complains of intermittent attacks of pain of a colicky nature, which recur at intervals, and become more frequent and prolonged as the case progresses. Vomiting is often but little marked during the intermissions. The bowels are irregular in their action, and there is sometimes a blood-stained mucous discharge. The general condition is not at first much affected, but as the case progresses, emaciation and general asthenia may supervene. On examination, the abdomen is found to be flaccid and free from tenderness, although visible coils of intestine may be observed in some cases, and perhaps a tumour felt. The symptoms are rather those of subacute enteritis and chronic obstruction than of strangulation, and the case may be brought to a fatal termination either by an acute attack of obstruction or by peritonitis. It may, however, last a long time before being recognised.

Treatment.—In the most acute forms of the disease but little can be done, owing to the extreme prostration of the patient; but in the less severe and in the chronic cases the results are generally satisfactory if the condition is recognised.

In acute intussusception the patient should be at once placed under the influence of opium, in order to still peristalsis and prevent the increase of the tumour. Inflation of the bowel with air, or the injection of copious enemata of warm water or oil, may then be carefully undertaken. No undue force should be employed in this proceeding, and a hand placed over the tumour may enable the surgeon to detect whether or not it has been successful. It is performed by raising the patient's pelvis and inserting into the rectum a catheter, with which is connected an indiarubber tube and funnel, held about 1½ or 2 feet above the abdomen. Should this not succeed, laparotomy should be performed without delay, and the condition of the intussusception investigated. An attempt is then made to reduce it by grasping the tumour in one hand and gently trying to peel off the ensheathing layer from the upper portion of the bowel, which is steadied by the other hand. In about half the cases reduction is impracticable, owing to the presence of adhesions, and then, if the general condition of the patient is fairly good, the intussusception should be removed and the divided ends of the bowel united by suture. If, however, the patient is in a condition of profound shock, all that can be done is to fix the bowel in the wound and make an artificial anus. The results of these procedures are anything but encouraging, as it has been shown that few children recover if anything more than simple reduction is required during a laparotomy.

Chronic intussusception is more favourable in its prognosis. It is frequently unrecognised until an exploration of the abdomen is made, and hence reduction by inflation is not commonly attempted. In some cases the tumour may be reduced by simple manipulation, but as a rule too many adhesions are present. Excision of the mass should then be undertaken, and the results gained have been very encouraging.

Diagnosis and Method of Examination of a Case of Intestinal Obstruction.

A grave responsibility rests upon the medical attendant in every case of obstruction. The condition is incompatible with life beyond a few days, and the time occupied in observing the patient and making up one's mind as to the nature of the case is valuable time lost, which may ruin the patient's chances of recovery. There are three things to be avoided in conducting a case of this nature: (i.) *Purgatives.*—The patient has probably taken plenty before sending for assistance, and the only result to be expected is an increase of pain and vomiting. (ii.) *Opium* has its place in the treatment of obstruction—viz., in relieving the agony associated with its onset; but beyond this it merely masks symptoms, and can do no good but comfortably to conduct the patient to the grave. It causes intestinal paralysis, and therefore may check the most distressing symptom, vomiting, but it aggravates the condition which needs treatment. (iii.) *Delay* in sending for surgical assistance is responsible for more deaths than is the condition itself. When once the gut has become generally paralyzed, there is but little hope for the patient.

In the investigation of a case various problems of some difficulty have to be solved, and it is well to undertake this task methodically.

1. The medical attendant must satisfy himself that obstruction is present, and not merely aggravated constipation. In the latter, however, flatus passes readily, and the general condition is not much impaired. In obstruction there is usually a complete arrest of flatus, and abdominal pain and vomiting often point to the existence of some serious lesion.

2. It is essential to ascertain whether the obstruction is *dynamic* or *mechanical.* The differences and distinctions between these have been already alluded to (p. 1126).

3. The question as to whether the lesion is *acute* or *chronic* must next be settled. Initial severe pain and collapse, the rapid onset of vomiting, a localized spot of fixed tenderness, and the quick depreciation of the patient, all point to some acute vascular lesion of the intestinal wall, which will prove fatal in a few days unless suitably treated. On the other hand, chronic cases are often preceded by constipation and other troubles of defæcation; they come on gradu-

ally, and are at first unaccompanied by constant pain and vomiting, although colic of a severe type may be present. The examination of the abdomen is also of the greatest assistance; in acute cases intestinal paralysis dominates the picture; in chronic cases, vigorous peristalsis can be felt and often seen, unless the patient has been left too long.

4. An effort must be made to determine the *site and nature* of the lesion. As to the question of site, the following points may be noted:

(*a*) When the *upper part of the small intestine* is involved, the vomiting is early, tumultuous, and persistent; the vomit is bilious, but not fæcal. Abdominal distension involves the epigastrium, and particularly the stomach. The lower part of the abdomen may be retracted. Collapse is early and rapidly increases. The thirst is terrible, the urinary secretion slight or even suppressed; gas and fæces may pass from the lower bowel.

(*b*) When the *lower part of the small intestine or cæcum* is involved, fæces and flatus cannot pass; the vomiting becomes offensive, but scarcely fæcal; meteorism is marked, and involves the central part of the abdomen, the flanks not being affected. In chronic cases peristalsis is very evident.

(*c*) When the *colon* or *rectum* is the site of obstruction, the symptoms are more chronic as a rule, and even in acute cases, such as volvulus, the initial collapse is slight. Vomiting is later in appearing, but may, of course, become fæcal. Meteorism may be very marked, and involves the flanks as well as the centre; sometimes it is possible to recognise that the lesion is not lower than the splenic flexure by distension of the left flank being absent.

The determination of the *nature* of the case will largely turn on the patient's previous history, and not uncommonly one has to admit that, although one can locate the site of mischief, there is no clue as to its nature beyond the generalizations learnt from statistics.

The actual examination of the patient is carried on along the following lines:

1. The **Previous History** of the case should be carefully gone into, in order to ascertain whether or not the patient has suffered from biliary colic, chronic constipation, acute diffuse or localized peritonitis, uterine derangements, syphilis or dysentery, etc.

2. The **History of the Present Attack** should then be ascertained, noting especially the manner of onset, whether acute or gradual, the duration of the symptoms, and whether or not preceding subacute attacks have occurred from time to time.

3. The more prominent **Symptoms** must then be considered.

(*a*) *Collapse* is due partly to reflex nervous disturbance, partly to the absorption of toxic materials, and partly to withdrawal of fluid from the body as a result of the vomiting; the portal area is also much engorged, and this adds to the want of fluid in the systemic circulation. The nervous cause is most active in the early stage of acute obstruction, especially in infants, whilst the toxic is largely responsible for the exhaustion seen at the end of an acute attack or in the chronic variety. Hence collapse is early in acute cases, late in chronic. Moreover, the higher the lesion, the greater the shock, owing to the fact that the upper portion of the bowel is more intimately associated with the sympathetic nervous centres.

(*b*) *Pain* is a very marked symptom, being usually referred at first to a little above the umbilicus, and is more severe in lesions of the small intestine than in the colon. It varies greatly with the completeness or not of the obstruction. This matter has been especially emphasized by Treves, who has pointed out that when the obstruction is only partial, the pain is intermittent; but when the block is complete, the pain becomes continuous. Hence in acute strangulation pain is almost invariably constant, whereas in stricture it is markedly intermittent and of a colicky nature. The amount of pain, moreover, varies with the nervous excitability of the patient; it is increased by anything which induces peristalsis (*e.g.*, food or purgatives), and it is diminished on the supervention of gangrene.

(*c*) *Abdominal tenderness* is rarely observed in the early stages, being caused by the onset of peritonitis.

(*d*) *Vomiting* is an almost invariable accompaniment of obstruction. Its cause has been already discussed (p. 1125). When the obstruction is situated in the jejunum or upper part of the ileum, the vomiting is never absolutely fæcal, although, if it has been temporarily checked by opium, the ejecta may be exceedingly offensive and dark in colour, owing to decomposition; fæcal or stercoraceous vomiting can only come from an obstruction to the lower ileum or colon.

(*e*) *Constipation*, although usually present, is not necessarily absolute, as it is possible for the lower bowel to be emptied in cases of obstruction, whilst the patient sometimes passes a motion as gangrene supervenes or death is approaching.

4. A most careful **Physical Examination** must now be instituted.

(*a*) *An inspection* of the uncovered abdomen should first be made. The amount and character of the distension is observed, and whether or not it is situated in the centre, as when small intestine is involved, or in the flanks when the obstruction is in the rectum or sigmoid flexure. The existence of visible peristalsis or enlarged coils of intestine should be noted; such are rarely seen in the acute cases, but may be very evident in the chronic forms. Sometimes one coil remains persistently distended and always at the same spot; its appearance always suggests that the site of obstruction is not far away. The rise and fall of the abdomen during respiration should be watched to ascertain whether the movements are equal on both sides, or if any prominence, such as would be caused by a tumour, is noticeable. The general condition of the patient, whether emaciated or not, as also the appearance of the face and the position in which he lies, should be observed.

(*b*) All the normal and abnormal hernial apertures are thoroughly investigated, and a careful examination made from the rectum and vagina.

(*c*) The abdomen is carefully palpated, so as to ascertain the existence of any tumour or increased resistance of the abdominal walls.

(*d*) *Percussion* may also throw some light on the case.

(*e*) Finally, some information may be gained by the use of *enemata*. When the obstruction is low down and not far from the anus, it may be impossible to introduce more than a small quantity of fluid, and this in spite of modifying the position. Too much reliance, however, must not be placed on this sign. It is also desirable to auscultate the colon during the administration of a large enema; it is sometimes possible to hear gurgling sounds as far round as the cæcum, indicating that the large intestine is free from obstruction. We would call attention here to the fallacy of using a long tube in the expectation of being able to pass it into the sigmoid flexure. A careful study of the rectum and its valves will show the difficulty of this, whilst the use of the genu-pectoral position renders it unnecessary.

CHAPTER XXXVIII.

AFFECTIONS OF THE RECTUM AND ANUS.

The rectum from the anatomical standpoint consists of the lowest 4 inches of the intestinal canal, but for the surgeon it represents the lower 6 or 8 inches which can be reached more or less from the anus. *Examination of the rectum* is carried out by the following methods:

1. **Digital Examination** in which the index finger is inserted through the anus. Soap should be smeared under the nail and into the semilunar fold at its base, so as to prevent fæcal matter from lodging, and vaseline may be applied both to the finger and to the anus to facilitate introduction. It is, of course, advisable to have the bowel unloaded by purgative or enema before an examination is made. The patient lies on the left side in the gynæcological position, and the introduction of the finger is usually less painful if he strains down at

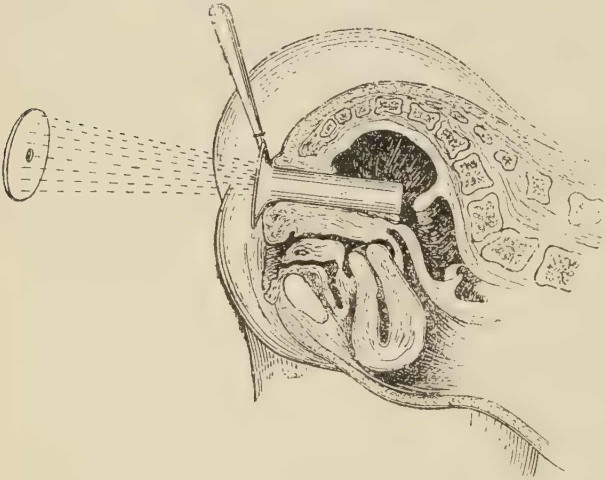


FIG. 525.—EXAMINATION OF THE RECTUM BY MARTIN'S PROCTOSCOPE.

The patient is in the genu-pectoral position, so that when the proctoscope is introduced air rushes in and distends the rectum; the observer, utilizing either an electric head-lamp or a laryngoscopic mirror, can easily see the interior. In the above diagram the projection of Houston's valves is clearly indicated.

the same time. A bimanual examination can be conducted with the finger in the rectum, and the other hand pressed deeply over the patient's hypogastrium. Although the great majority of rectal lesions occur within the lowest inch and a half of the bowel, the surgeon must never omit to explore the upper part of the rectum, as an unsuspected polypus or tumour may often be discovered in this way; the pelvic parietes should also be included in the scope of the investigation.

2. The introduction of the whole hand has been recommended by some, but the hand must be unusually small which can be thus utilized.

3. **Visual Examination** is a most valuable proceeding. Martin's *proctoscope* (Fig. 525) is the most suitable appliance to use for this purpose, but an ordinary Fergusson's speculum answers well. The patient is placed in the genu-pectoral or in an elevated lithotomy position; the former is preferable, in that it allows intestines and uterus to drop forwards away from the rectum. Two index fingers, well greased and held back to back, are then introduced into the bowel, and the anus stretched in several axes, so that its muscular tone is lost for a time. The proctoscope can then be introduced, and it will be found that if the patient is in the correct position the rectum becomes ballooned by an inrush of air, and its interior can be clearly seen; a head-lamp or a laryngoscopic mirror is sometimes useful in order to illuminate the interior. Houston's valves stand out clearly, and often obstruct the view of the upper part, but they can usually be pulled aside by a hook, or pushed aside by the speculum, or even if necessary they can be divided. In this way 6 inches, if not more, of the bowel can be brought under the eye of the surgeon, and topical applications can be made.

A *sigmoidoscope* may be employed for seeing the condition of the upper part of the rectum and of the lower end of the sigmoid flexure. It consists of a hollow straight tube, 14 inches long, with its length marked on the outside so that one may know how far it has been introduced. Suitable arrangements are made for distending the bowel with air, and for illuminating and seeing its interior. A blunt-ended obturator is used to facilitate its introduction in the first instance, but this is withdrawn when it is well into the bowel.

Congenital Malformations—Imperforate Anus or Rectum.—The lowest portion of the intestinal canal arises from the union of two separate divisions. The upper, developed from the lowest portion of the primitive hind-gut, is originally in communication with the bladder, and forms a joint cavity or cloaca, the two, however, being early separated; the posterior segment, which becomes the rectum, extends down into the pelvis, to be joined by an epiblastic pit or involution growing in from the perineum known as the 'proctodeum.' Failures in typical development may be due either (*a*) to the proctodeum being absent or stenosed; (*b*) to the rectum being absent (Fig. 526, A) or retaining in measure its cloacal condition and opening into some other viscus—*e.g.*, the bladder, urethra, vagina, or vulva (Fig. 526, B); or (*c*) to want of union between the upper and lower segments (Fig. 526, C). The following are the chief clinical varieties of malformation met with:

(i.) Absence of the anus, with or without development of the rectum, which, if present, may open in some abnormal situation. In these cases, the important question to be settled by the practitioner is the existence or not of a rectum, and this, unfortunately, cannot always be determined without an open exploration through the perineum; if, however, during crying and straining there is a distinct bulge in the middle line at the spot where the anus should be, there is every likelihood of the viscus being present. If so, it is always distended and club-shaped, usually lined with peritoneum in front, and often below. If the rectum is absent, it usually ends near the pelvic brim, and is merely represented by a fibrous cord below that level (Fig. 526, A), whilst the bony pelvis is often atrophic and its outlet much reduced in size. Thus in one such case an interval of only ½ inch was present between a sound passed into the urethra and the tip of the coccyx.

(ii.) A membranous septum may persist between the upper and lower segments, placed about an inch from the anus, and allowing the retained meconium to push it downwards. This is the type of malformation most commonly observed (Fig. 526, C).

(iii.) An anus is occasionally present, whilst the rectum ends blindly above the pelvic brim, or opens elsewhere.

(iv.) The anus, though present, may be contracted.

The **Treatment** of these cases must be instituted at as early a date after birth as possible, so as to prevent intestinal obstruction.

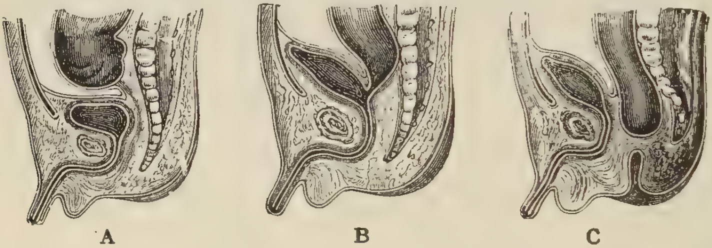


FIG. 526.—THREE VARIETIES OF MALFORMATION OF RECTUM. (TILLMANNS.

In A the bowel ends at the brim of the pelvis in a cul-de-sac, and there is no evidence of an anus; in B the anus is also absent, but the bowel opens into the bladder; in C the anus and bowel are only separated by a small space.

Anal stenosis is readily dealt with by regular dilatation with bougies.

Where a membranous septum persists between the proctodeum and rectum, a large trocar and cannula may be passed through it, and the meconium allowed to escape; the aperture thus made is enlarged, and maintained by the subsequent passage of bougies.

Where the anus is absent, whether there is any indication of the presence of a rectum or not, a *perineal incision* is first made through the site of the anus, and carried upwards and backwards along the concavity of the sacrum strictly in the middle line for not more than 2 inches. It is an open question whether it is justifiable to proceed further by removing the coccyx and part of the sacrum (Kraske's operation, p. 1171), since the membranes of the spinal cord extend much further down in the infant than in the adult. If found, the dilated and bulbous cul-de-sac is drawn down as far as possible, and opened towards its posterior aspect; the mucous membrane is then, if feasible, stitched all round to the skin so as to leave no surface to granulate, thereby preventing subsequent stenosis. In cases where no rectum is present, *colostomy* must be performed, and by preference the iliac operation, since the space between the crest of the ilium and the last rib is exceedingly small in an infant. When once a passage for the fæces is established, abnormal openings into the bladder, etc., usually close without difficulty.

Various malformations in connection with the post-anal gut have been already described (p. 703).

Injuries of the rectum are usually due to falling on some pointed body, such as a stick or railing, or upon a piece of broken china. They are sometimes due to the forcible introduction of foreign bodies by lunatics or criminals. They may merely involve the mucous membrane, or may penetrate the perineal tissues, enter the bowel, and penetrating the upper wall, lay open the peritoneal cavity. Hæmorrhage, pain, and shock follow, and acute peritonitis if the serous membrane has been encroached on. Inflammatory troubles may involve the peri-rectal tissues, and sinuses may result from suppuration. A thorough examination must be made under an anæsthetic, and the wounds either sutured or left open to granulate. In women the recto-vaginal septum may be torn, but the surgeon need be in no great hurry to interfere, since the opening usually closes as cicatrization progresses; in some cases, however, where the lesion is of some length, and the margins not bruised or inflamed, immediate suturing may be desirable. If the peritoneal cavity has been laid open, a laparotomy is usually required in order to cleanse it and close the wound; if, however, the wound is small and the rectum at the time of injury empty, it may be justifiable to delay interference till some sign of inflammatory reaction shows itself; a piece of sterilized gauze packing in the rectal wound will often suffice to limit the inflammatory mischief. Peri-rectal complications are dealt with as they arise.

Foreign Bodies are derived from various sources. Generally they have been swallowed, and have traversed the intestinal canal. Fish-bones and small tooth-plates are most commonly seen, and they usually lodge just above the anus in one of the so-called ‘ pouches of Morgagni.’ They give rise to severe pain, especially on defæcation, and possibly to some form of peri-rectal abscess. Large gall-stones are sometimes lodged in the lower end of the rectum, just above the sphincter. Foreign bodies may be introduced from without, and cause various forms of traumatic inflammatory lesions.

Inflammation of the Rectum (*Proctitis*) causes pain of a bearing-down character, a sensation of fulness, constantly recurring tenesmus, accompanied by a discharge of mucus, muco-pus, or blood. It may arise from any local source of irritation—*e.g.*, the presence of foreign bodies, or of a polypus, parasites, or piles; gonorrhœa is an occasional cause—in women possibly owing to infection from the vaginal discharge, in men probably from direct infection. In dysentery the rectum is often involved as well as the colon, and extensive ulceration may be present. If the inflammation becomes chronic, a simple fibrous stricture may result. *Treatment.*—Injections of lead and opium or of borax may be used locally, whilst the patient is kept in a recumbent position and on a low diet, the bowels being regularly opened by the administration of laxatives or enemata. If much bleeding is present, hazeline will often serve as a useful styptic.

Thread-worms (*Oxyuris vermicularis*) are the most constant source of irritation of the rectum in infants and children. They give rise to pruritus ani, a discharge of muco-pus, and many reflex phenomena. In treating such a case, a sharp purgative may be given every morning (*e.g.*, pulv. scamm. co., grs. v.), and salt and water or an infusion of quassia used as an injection. Occasionally this is ineffective, and then it is possible that the cæcum or even the appendix is the main site of lodgement of the worms; santonin may then be necessary in order to clear the intestinal canal.

The **Bilharzia hæmatobia** is occasionally found in the rectum as well as in the urinary passages (p. 1182). It gives rise to fibro-adenomatous polypi, in which the ova can be readily demonstrated; they are rounded or oval bodies, differing from those found in the urine in that they possess a lateral spine-like projection, whilst in the latter it is terminal. Considerable tenesmus, diarrhœa, and discharge of blood are present, and the hæmorrhage may become so abundant as to destroy the patient's life, especially when urinary symptoms are co-existent. They occur in children who have been in South Africa, and, unfortunately, no satisfactory treatment is known.

Rectal and Peri-rectal Suppuration.—Many forms of abscess are found in and about the rectum, and they are very liable to leave behind troublesome fistulous tracks. As regards causation, they are, of course, due to germs, and these are derived most commonly from the bowel as a result of the impaction of foreign bodies, the extension of ulcerative processes, or the suppuration of piles. Occasionally the trouble starts from the skin around the anus, and sometimes the pus reaches the peri-rectal tissues from other viscera —*e.g.*, the neck of the bladder, prostate, etc.—or from above, in connection with spinal or pelvic abscesses. Not unfrequently the abscess is attributed to injury or to cold, as from sitting on a damp stone or a draughty closet. These latter, if having any influence, are merely the final exciting agents.

1. An **Anal Abscess** forms immediately under the anal integument, and superficial to the external sphincter (Fig. 527, A.A.); it is usually due to inflammation of one of the numerous sebaceous follicles in that locality. It may be acute or chronic, and is one of the most frequent causes of fistula-in-ano. It must be freely opened throughout its whole length, and packed.

Occasionally a sebaceous follicle becomes affected, constituting a boil, and may infect several others. If these can be dealt with early, the trouble may be limited, but if neglected a somewhat extensive anal abscess may result.

2. A **Submucous Abscess** (Fig. 527, S.M.A.) usually forms as the result of a suppurating internal pile. The pus spreads up and down under the mucous membrane, and gives rise to a blind internal

fistula (Fig. 529, 5). It is usually confined to one side of the bowel, and causes great pain on defæcation. Digital examination is extremely painful. **Treatment** consists in draining it at the most dependent spot, close to the anus, but it may be necessary to slit up the undermined mucous membrane in order to ensure healing. Considerable hæmorrhage may follow this proceeding, and it is not easy to stop except by firm pressure.

3. **Acute Ischio-rectal Abscess** is due to infection of the loose fatty tissue filling the ischio-rectal fossa (Fig. 527, I.R.A.) with some pyogenic organism, reaching it either through the perineum or from the bowel. The *B. coli* is usually present, and in consequence the pus has the ordinary characteristic offensive odour. A red, painful swelling is noticed on one side of the anus, which is at first hard and brawny, but soon becomes soft and fluctuating. Defæcation is exceedingly painful, as also digital exploration of the bowel, and the patient is unable to sit with any comfort. If left to itself, it may burst internally or externally, or in both directions, and a fistula-in-ano is very liable to follow. **Treatment.**—In the early stages the part should be well fomented, but when there is no doubt that pus is present, a free opening should be made, the cavity washed out, and packed with some antiseptic dressing. If taken early enough, rapid recovery may ensue without the bowel becoming involved, but when the mucous membrane has been encroached upon or perforated, the wound will not heal without division of the sphincter. A T-shaped or crucial incision is perhaps the best to employ in the early stages, as indicated in Fig. 528; the cross limb of the T is parallel to the fold of the nates, and should extend through the whole of the inflamed and infiltrated tissues.

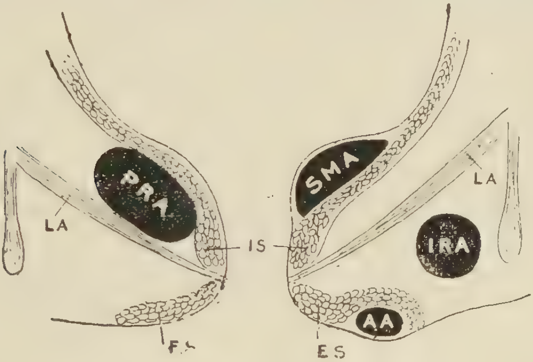


Fig. 527.—Diagrammatic Section of Abscesses situated near the Lower End of the Rectum.

L.A., Levator ani; E.S., external sphincter; I.S., internal sphincter; I.R.A., ischio-rectal abscess; A.A., anal abscess; S.M.A., submucous abscess; P.R.A., pelvi-rectal abscess.

4. **Chronic Ischio-rectal Abscess** is usually met with in run-down or tuberculous individuals during young adult life, and is not unfrequently a complication of phthisis. A deposit of tuberculous material replaces the fat ordinarily occupying the ischio-rectal fossa, and this after a time undergoes caseation or forms an abscess, which gradually spreads without pain or other inflammatory disturbance, until it may extend very widely and almost entirely surround the bowel. After it has burst the orifices of sinuses may be found at a considerable distance from the anus. The **Signs** and **Symptoms** are those of a chronic tuberculous abscess. An indurated and painless mass may be first felt in the fossa, and this slowly spreads, softens, and is transformed into a more or less extensive abscess sac. Operative **Treatment** is desirable in most of these cases, and if possible in the early stages, or before suppuration has occurred; incision, removal by a sharp spoon of all tuberculous tissue, the application of pure carbolic acid, and dressing the wound with gauze infiltrated with iodoform are the essential elements. Where extensive sinuses or fistulæ exist, treatment as for fistula-in-ano must be adopted. At the same time, suitable hygienic treatment is instituted, and the more so if physical examination of the lungs or bacteriological examination of the sputum indicates the co-existence of pulmonary tuberculosis.

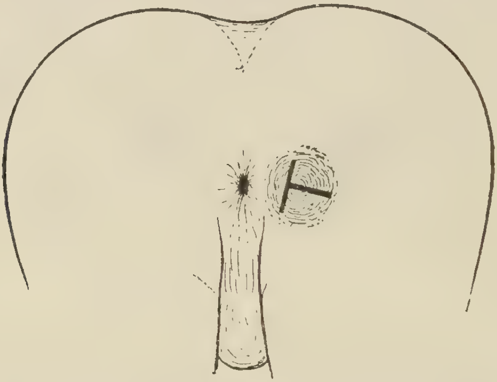


FIG. 528.—SITUATION OF T-SHAPED INCISION REQUIRED FOR OPENING AN ISCHIO-RECTAL ABSCESS.

5. The **Pelvi-rectal Abscess** (Fig. 527, P.R.A.) consists in a localized collection of pus in the loose cellular tissue above the levator ani between it and the rectum. It may be secondary to rectal lesions, such as penetration of the wall above the internal sphincter or extension of ulceration from a carcinoma; but not uncommonly it originates from pelvic lesions, and may be caused by pelvic cellulitis, or suppuration in the meso-rectum, prostate, etc. The ordinary phenomena of a deep abscess are produced, and the

pus may burrow downwards through the levator ani to the ischio-rectal fossa, or may travel up and involve the pelvic peritoneum. Sometimes it extends laterally and may almost surround the bowel, causing one type of horseshoe fistula. Other collections of pus may find their way into this region from different parts—*e.g.*, a psoas abscess from spinal disease, appendix abscesses, etc. Rectal examination indicates the existence of a painful swelling high up in the bowel. As soon as a diagnosis is made, the abscess should be freely laid open and drained, and, if possible, by an incision behind the anus. Of course an abscess which is secondary to a tuberculous spine is an exception to this rule; in this every effort must be made to prevent the necessity for an opening in this region, as infection is certain to follow.

6. Occasionally a *diffuse* form of cellulitis involves the peri-rectal connective tissue, not uncommonly resulting in gangrene (*gangrenous periproctitis*). It is most likely to be seen in weakly individuals and old people, and the symptoms are very asthenic in type. The suppuration may extend above the levator ani, and lead to deep fistulous tracks. The parts must be freely opened up, the gangrenous tissue scraped away, and the raw surfaces treated with peroxide of hydrogen. The wounds are then packed with iodoform gauze, and subsequently well irrigated twice a day. Free stimulation is always required in these cases, but the prognosis is very bad, death being probably caused by acute toxæmia or pyæmia.

Fistula-in-Ano.—The term 'fistula-in-ano' is somewhat loosely applied to all those conditions in which suppurating tracks are found in the neighbourhood of the anus and the lower end of the rectum. Many of these are merely sinuses which have but one opening.

The **Cause** of fistula is usually some suppurative condition—*e.g.*, an ischio-rectal or anal abscess, or the breaking down of a tuberculous deposit in the neighbourhood of the bowel; but it is sometimes the result of a simple or malignant stricture of the gut, the inner opening being either above, in the substance of, or below the cicatricial mass. This is more likely to be the case when multiple fistulæ exist.

Varieties.—1. The *Complete Fistula* is one in which there are openings both externally and into the bowel. When following an anal abscess, they are both close to the anus, and the track lies immediately beneath the skin and mucous membrane (Fig. 529, 1). When following an acute ischio-rectal abscess, the external opening is a variable distance from the anus, and the inner not more than 1 inch up the bowel, being situated in relation with the so-called internal sphincter (Fig. 529, 2); occasionally blind submucous or subcutaneous extensions are met with branching off from this (2^a), but not so frequently as when the fistula follows a chronic tuberculous abscess. In the latter case the skin may be extensively undermined, looking blue and congested, and the fistulous tracks may burrow widely, opening even on the thigh, or in the perineum or buttock. The so-called *horseshoe fistula* passes round the bowel, usually behind the anus, either superficial to the external sphincter or beneath it, and opens also on the other side. Moreover, the mucous membrane of the bowel is often undermined, and stripped from the muscular coat for some distance above the internal opening by sinuses or an abscess cavity. Occasionally the complete fistula which follows an ischio-rectal or pelvi-rectal abscess opens some way up the bowel as well as externally, and traverses the levator ani (Fig. 529, 3), constituting a much deeper and more serious lesion.

In any of these conditions secondary tracks may form, burrowing in all directions, and sometimes the opening up of these passages is a serious matter. Thus they may run forwards to the scrotum, or outwards into the gluteal region.

2. The *Blind External Fistula* (Fig. 529, 4) is the term applied to a sinus resulting from the opening of an ischio-rectal abscess in which no communication with the bowel can be discovered. A probe passed into the wound can often be felt by a finger in the rectum with only the thickness of the mucous membrane between. In dealing with these external fistulæ the possibility of the original cause being at a distance must not be overlooked.

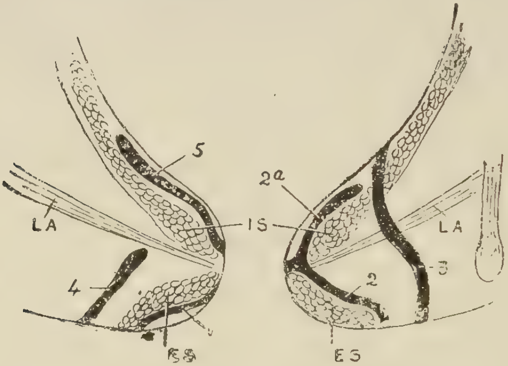


FIG. 529.—DIAGRAMMATIC REPRESENTATION OF VARIOUS FORMS OF FISTULA-IN-ANO.

1, Superficial fistula resulting from an anal abscess; 2, a complete fistula, not involving the internal sphincter; 2ª, secondary track burrowing under mucous membrane; 3, complete fistula opening above the internal sphincter and traversing the levator ani; 4, blind external fistula; 5, blind internal fistula; E.S., external sphincter; I.S., internal sphincter; L.A., levator ani.

3. The *Blind Internal Fistula* (Fig. 529, 5) is constituted by a sinus opening into the bowel just above the anus. Attention is usually drawn to the condition by the passage of pus with the motions or independently, and perhaps by preceding inflammatory disturbance. The orifice can sometimes be felt by digital exploration; on the insertion of a speculum it may perhaps be seen, and can be examined by a straight probe or one bent in the form of a hook; it is

often associated with considerable undermining of the mucous membrane, and if chronic with stenosis of the bowel.

In all these conditions it is difficult to obtain healing, owing to the introduction of septic material from the bowel, and to the state of unrest in which the parts are kept by the continuous movements, voluntary and involuntary, of the sphincters.

Operation.—The bowels must have been completely evacuated, both by means of castor oil or some suitable purgative, and about an hour previous to operation by enema, a most important preliminary, not only for the comfort of the operator, but also because it is very desirable that no further action should be required for some days. The patient is placed in the lithotomy position, and the perineal and anal regions shaved and purified. A probe is passed along the fistula into the rectum, and guided by it a grooved director, along which a curved pointed bistoury is introduced, and the intervening structures divided. In a superficial fistula, both sphincters may escape division, and in a deep one both may be involved; in the majority of cases, some fibres of the external sphincter are divided. A careful search is made for pockets or tributary branches of the main track, and these, if found, are opened up and scraped out, undermined and unhealthy skin being snipped away with scissors; it is important, however, to remember that the sphincter ought never to be divided in more than one place. Bleeding-points are, if necessary, tied, and the cavity is carefully dusted with iodoform, and lightly packed with oiled lint or gauze soaked in iodoform and glycerine. Pressure by a graduated compress of sterilized wool should be applied by means of a T-bandage.

When a sinus extends for some distance under the mucous membrane from the upper end of the original fistula, it may not be always desirable to lay it open to its whole extent, since such might involve serious hæmorrhage at a spot where it cannot well be checked. It will often suffice partly to divide and scrape it, and then, if the main fistula has been satisfactorily dealt with, it will probably heal without difficulty, especially if syringed out occasionally with stimulating lotions.

In the case of a horseshoe fistula, the sphincter need only be divided at one spot, and that usually in the middle of the horseshoe. The whole track must, however, be opened up, the cavity scraped, loose tags of skin removed by the scissors, and an ordinary dressing applied.

A small superficial fistula, not extending beyond the anal margin, can sometimes be entirely excised, and the wound closed by sutures, thereby securing healing by primary union.

After-Treatment.—The bowels should, if possible, be prevented from acting for four days, and most scrupulous care taken to keep the parts clean. The deep dressing need not be changed for the first twenty-four or forty-eight hours, provided that the surrounding skin is well flushed with a warm carbolic solution. When the plugs are removed, fresh small strips of gauze soaked in iodoform and glycerine are introduced night and morning after the wound has been syringed. On the fourth day a good dose of castor oil should be given, and subsequently an action of the bowels must be secured daily. The wound is allowed to granulate, and care taken that irregular healing does not lead to a re-formation of the fistula. With this object in view, it is often advisable to pass a moderate-sized bougie from time to time at the end of a fortnight.

When the incision is not carried very deeply, the patient's sphincteric control after operation is unimpaired; but if the internal sphincter has to be divided, all control of the bowel is lost for some time. As cicatrization progresses, however, it is gradually restored, and when healing is complete, control is usually perfect except when the patient is suffering from diarrhœa.

The presence of tuberculous material locally and in the lungs must be carefully considered and taken into consideration in advising operation. If the pulmonary trouble is early, there is no necessity for delaying operation; the patient will derive much more benefit from sanatorium treatment if his fistula has been first cured, or put well on the way to recovery. In the later stages, however, it may be advisable to leave the fistula alone, or, at any rate, only to do such an operation as shall relieve any urgent symptoms.

Fissure of the Anus.—This is a most painful and troublesome complaint, met with most commonly in men, though not unfrequently in women of a neurotic temperament. It is occasionally due to injury or to the irritation of a polypus, but more often to the passage of large scybalous masses in patients suffering from chronic constipation. The fissure is usually single, extending through the posterior border of the anus toward the coccyx; a 'sentinel' external pile is often situated immediately over it, and the crack may lead to a definite ulcer just within the external sphincter. According to Ball of Dublin, it is due to one of the valve-like tags, left at the junction of the proctodeum and rectum, being caught by a scybalous mass, and torn from its upper connections. Each time a motion passes the sore place is reopened, and the valve pushed further on, until finally, having become swollen and œdematous, it appears at the orifice as the 'sentinel' pile, with an ulcerated surface behind or beside it. Sometimes several fissures are met with in the same individual, and then a syphilitic cause is probable, especially if they are placed at the side or front of the anus.

The **Symptoms** of this condition are very distressing, consisting of burning pain during and after defæcation, which often lasts for hours. The pain is usually associated with tenesmus, and may radiate down the thighs or up the back, and not uncommonly to the left sacro-iliac joint; it may be so severe as to lead the patient to refrain from defæcation for prolonged periods. The fæces may be streaked with blood or pus, and there is a certain amount of discharge from the anus. On examining the part, the sphincter is found to be contracted spasmodically, and the entrance of a finger is forcibly resisted.

Treatment in the earlier stages is undertaken by regulating the action of the bowels by suitable laxatives, by the use of cocaine suppositories prior to defæcation, and by improving the general health. Sometimes the application of a hamamelis ointment, combined with the Ung. hydrargyri nitratis dil., is most effective in giving relief. In confirmed cases the sphincter has been forcibly dilated, and the crack or ulcer cauterized; but by far the most satisfactory treatment consists in dividing its base with a straight blunt-ended bistoury, the incision at the same time including the superficial fibres of the external sphincter. The ulcer and the edges of the wound are snipped away with scissors, to facilitate the dressing and healing of the wound. The lower bowel should in all cases be carefully explored with the finger, especially with a view to the possible existence of a polypus, which, if undetected, would cause a recurrence of the mischief. Rest being thus obtained, healing soon follows. It is sometimes possible to close this small wound with sutures and obtain primary union.

Pruritus Ani is a condition characterized by intense and incessant itching of the anus and its surrounding skin. At first noticed mainly at night, and interfering with sleep, it may in time become persistent throughout both day and night, preventing the patient from fixing his attention on his work, and wearing him out through want of sleep. Scratching becomes a necessity, and yet aggravates the condition. It is generally due to parasites, such as thread-worms, or to some ulcerative condition of the anal canal, just at the muco-cutaneous junction, or it may arise from some neurosis of the sensory nerves. The skin looks red and excoriated; it is usually swollen and thrown into œdematous folds, which radiate from the anus in a characteristic fashion.

Treatment.—Any parasites present must be destroyed, and ulcers of the anal canal must be carefully looked for and cauterized. For cases which persist in spite of such measures, Sir Charles Ball has devised an operation which has proved of value, and consists in dividing the terminations of all the sensory nerves to the part. Two semi-elliptical incisions are made around the anus, leaving a narrow pedicle in front and behind; the wounds are deepened to expose the sphincter, and the flaps raised from the muscle inwards around the anal margin and up to the muco-cutaneous junction. The pedicles in front and behind are undercut, and the outer margins of the incisions also to an extent corresponding to the area of irritation; the flaps are then replaced and sutured. The immediate result of such an operation is complete anæsthesia of the skin of the flaps; normal sensation returns after a time, but without pruritus.

Hæmorrhoids, or Piles, consist in a varicose condition of the veins surrounding the anus and lower inch or two of the rectum.

The character of the blood-supply of this portion of the bowel, and the conditions under which it is carried on, go far to explain the frequency of this affection. The circulation in the pelvic colon is similar to that in the intestine generally, the vessels being distributed transversely around the gut; but in the rectum they run in longitudinal series along the bowel, being connected by transverse branches, which form a plexus around and just above the anus. Their situation in the loose submucous tissue, where there is but little support, necessarily exposes them to great and sudden variations of pressure before and after defæcation. Their dependent position at the lowest part of the portal area, together with the absence of valves, and the fact that they constitute an important communication between the portal and general systems, and thus afford the chief means of escape from a block on the portal trunk—all these reasons may be looked on as **Predisposing Causes** of the condition. In addition to these we must also mention a sedentary occupation, alcoholic excess, and chronic constipation, which, by leading to congestion of the liver, are frequent precursors of piles. They are exceedingly common in young people, especially in men about twenty years of age forced to lead a sedentary life; up to middle age the tendency diminishes, but in elderly individuals many conditions—*e.g.*, enlarged prostate, or stone in the bladder—arise which favour their development. Simple stricture of the rectum or malignant disease may so interfere with the return of blood as to determine a development of hæmorrhoids. Young women are remarkably exempt from piles, owing probably to the regularity of the menstrual discharge; but uterine conditions, such as pregnancy, displacements, or tumours, which cause obstruction to the venous return, are liable to be associated with them.

A varicose condition of the veins in the neighbourhood of the anus is often present without being recognised by the individual; but many different circumstances may bring the symptoms into prominence by causing an attack of thrombosis, such as the use of drastic purgatives, especially aloes, local exposure to damp and cold, as by sitting on a cold wet stone or in a draughty closet, or sudden congestion of the liver, as by alcoholic excess, or a chill.

Two chief varieties of piles are described—viz., the external and internal; but frequently a combination of the two conditions is present.

External Piles are found at the margin of the anus, and are covered with skin. They consist of a small central vein in a varicose state, surrounded by a development of subcutaneous fibro-cellular tissue, which latter is much more abundant than the vascular element; in fact, they practically consist of longitudinal folds of skin of a dark brown colour radiating from the anus, and superficial to the sphincter. In the usual relaxed state in which they are found they give rise to no **Symptoms** beyond a little pruritus, and perhaps a sense of fulness and irritation immediately before and after defæcation. They are very liable, however, to become *inflamed* from local irritation or cold, and then appear as tense, bluish, rounded swellings, exceedingly painful and tender, and often preventing the patient from walking or sitting in comfort. In such a state the vein contained in the pile is distended with blood-clot. Under suitable treatment the swelling subsides in a few days, usually leaving the fleshy fold more bulky and harder than previously, owing to the partial or complete organization of the thrombus.

The **Treatment** of external piles, when uninflamed, is very simple. Constipation must be relieved; the parts should be kept clean and well washed; a hamamelis ointment or extract may be occasionally applied, and great care taken not to irritate the anus after defæcation by the use of hard paper—*e.g.*, newspaper. Very soft curl-paper, well crumpled, should be employed, or preferably absorbent wool. It is but rarely that *operative measures* are required in a simple case of external piles; where, however, external and internal piles co-exist, it is advisable to complete any operation undertaken for the latter condition by the removal of the more prominent fleshy folds surrounding the anus. This is accomplished by grasping them with forceps, and snipping them away by scissors in a direction radiating from the centre of the anus, the resulting wounds being sutured. For inflamed and thrombosed external piles the patient should be kept in bed, the bowels opened by a copious warm enema, and fomentations applied. If the pain and tension are very great, the tumour should be incised and the clot turned out; the margins of the fold may then be cut away, and the wound dressed.

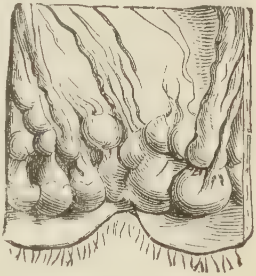


FIG. 530.—INTERNAL PILES.

Internal Piles consist of dilated veins held together by a certain amount of connective tissue, and covered by mucous membrane. At first they are quite soft and compressible, and easily emptied on pressure; but when they have existed for some time the connective tissue may be increased in amount, and arterial twigs are often found running into the mass.

The condition is limited to the lower 2 inches of the bowel, and may present very varied appearances in different cases. Thus, there may be a general dilatation of the veins in the submucous tissue without the formation of any distinct tumours. The mucous membrane is then of a deep claret colour, somewhat thickened, and liable to protrude during defæcation. There is a certain amount of glairy mucous discharge, and the fæces may be streaked with blood; but, as a rule, the hæmorrhage is not great. Such a condition is usually followed by a definite formation of hæmorrhoidal tumours, and not unfrequently runs on to prolapse.

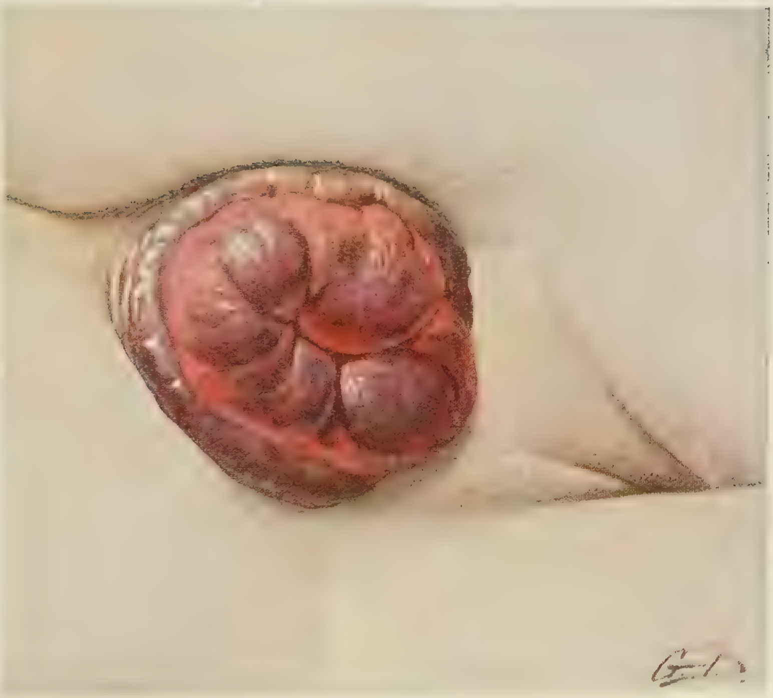
When distinct hæmorrhoidal masses form, they may be of two types: (*a*) The *longitudinal* or *fleshy pile* (Fig. 530), consisting of broad sessile masses, dusky in colour, soft and compressible in consistency, and covered by mucous membrane, which, although thin and stretched, still remains smooth and shiny, like the skin of a black grape. Between the piles depressions are found, in which small portions of fæces may lodge and produce irritation. This form generally bleeds but little. (*b*) The *globular* or *bleeding pile* is single or multiple, and as a rule somewhat pedunculated; the surface of the tumour is roughened and granular, like a strawberry, due to the existence of dilated capillaries. When, however, a portion of it has been repeatedly protruded, the exposed mucous membrane becomes hard, and practically converted into skin, and the columnar epithelium may be replaced by the squamous type. The hæmorrhage may be abundant, and comes either from the dilated superficial capillaries, or occasionally from a central arterial twig.

The **Symptoms** arising from internal piles are often not very marked until hæmorrhage occurs; but there is usually a sense of weight or fulness about the anus, with sometimes pain, which is increased before and after defæcation. The patient feels as if a foreign body were present in the bowel, and the mass not unfrequently protrudes, giving rise to much pain and inconvenience until replaced by the patient, owing to the grip of the sphincter (Plate XI.). Sooner or later hæmorrhage is almost certain to be noticed, coming on at first after defæcation, and only a few drops being lost. After a time, however, the flow increases, and may continue to such an extent as to cause marked anæmia. If the case remains untreated, the pain and inconvenience increase; a blood-stained mucous discharge from the rectum is noticed, soiling the linen; reflex irritation of neighbouring organs is produced, and a condition of nerve prostration from pain and hæmorrhage may result. In cases where the piles are due to portal obstruction, as in cirrhosis of the liver, the bleeding may be beneficial, and must not always be checked.

Complications of Piles.—*Inflammation* of the venous ampullæ contained in piles leads to what is popularly termed an ‘ attack of piles,’ although this is much less common with the internal than the external variety, and the fleshy form is that usually affected. Evidences of a localized phlebitis manifest themselves in the shape of a painful distension and swelling of the parts, which become blue in colour and exquisitely sensitive. They subside with or without suppuration; in the latter case a spontaneous cure may result, whilst in the former the abscess may burst into the bowel or may burrow extensively, and even give rise to general blood contamination and pyæmia. *Strangulation* of the piles by the sphincter ani may follow protrusion where reposition is not effected, the mass becoming painful, tense, swollen, and livid in colour; inflammation running on to ulceration and sloughing follows, the patient suffering from sickness, pain, and toxæmia. Pyæmia may ensue, or a spontaneous cure be effected.

The **Diagnosis** of piles from other swellings which occur in the neighbourhood is not difficult. From *prolapse* they are recognised by their irregularity, the swelling not being of a rounded smooth annular variety, as in the former case; the two conditions are, however, often associated. From *polypus* piles are distinguished by

PLATE XI.



Prolapse of mucous membrane of Rectum and Hæmorrhoidal tumours in an old standing case of Piles. This case was treated most effectively by Whitehead's operation.

[*To face page 1158.*

being multiple rather than single, by being softer and more compressible, by their situation close to the anus, by the absence of a pedicle, and by the hæmorrhage being usually more marked. *Mucous tubercles* and *condylomata* are often mistaken for external piles, but are easily recognised by being symmetrically placed, owing to infection of one lip of the gluteal fold from the other, by their moist surface, and their situation at a little distance from the anus. The consistency, appearance, and history of an *epithelioma* should effectually prevent any error in diagnosis.

It is important also to remember that blood may be passed *per anum* from many other conditions besides piles. In the latter case the blood is of a bright red, florid colour, and often coats the fæces, whereas if it originates higher in the intestinal canal it is dark or tarry in colour (*melæna*), and is more intimately mixed with the excreta. A visual and digital examination of the rectum should always be made in order to ascertain the exact cause of the bleeding.

The **Treatment** of internal piles is both general and local.

General Treatment consists in removing all possible sources of venous congestion, in regulating the bowels, and assisting the functions of the liver. The latter may be effected by the judicious administration of natural mineral waters, such as Hunyadi Janos and Friedrichshall, or by the use of some such mild aperients as the confections of senna and sulphur, or castor oil; aloes should generally be avoided. At the same time the food is regulated, alcohol forbidden, and suitable exercise enjoined. When dependent on the pressure of a gravid uterus, little can be done beyond attending to the regular action of the bowels until the child is born.

Local Treatment in the earlier stages consists merely in *palliative* measures. Thus the parts must be protected from injury and cold; only soft paper or cotton-wool used after defæcation; and when protruding, the piles should be sponged with cold water and gently returned. An ointment containing an extract of witch-hazel (hamamelis), or the injection of a hazeline lotion (1 in 8), is also advisable, and bleeding from piles can often be arrested by this means. The Ung. gallæ c. opio of the Pharmacopœia is often employed, but is not so efficacious.

When there is much pain or bleeding, and the piles have attained some size, **Radical Treatment** by operation is necessary. Care must be taken before advising it to ascertain that no other serious disease of the rectum—such as cancer—is present, and that the piles are not dependent on hepatic or cardiac disease, when an operation might be injudicious and harmful. In all cases the bowels are thoroughly emptied by a dose of castor oil given the night before and an enema on the morning of the operation, whilst the patient sits over hot water for half an hour beforehand. The lithotomy position is adopted, the perineum is shaved and cleansed, and the surgeon thoroughly stretches the sphincter by introducing the two index fingers and then separating them forcibly, by this means bringing into view the whole of the diseased area of mucous membrane, which never extends beyond 2 inches from the anus. The following plans of treatment are those chiefly used:

1. *Removal by clamp and cautery*, as introduced by the late Mr. Henry Smith. The mucous membrane having been everted, as just described, each of the hæmorrhoidal tumours is grasped by a pair of ring-ended catch forceps, and thus temporarily secured; by this means the scope of the operation required can be readily gauged. The clamp is then applied to each mass successively in a direction corresponding to the long axis of the gut, great care being taken not to include the external skin. The clamp is tightened by the screw attached to its handle, and the projecting mass of the pile removed by scissors. The cut surface is then thoroughly seared by a cautery at a dull red heat, and the pressure of the clamp slowly relaxed, so as to ascertain that all bleeding has ceased. External piles may be snipped away as indicated above (p. 1157), the mucous membrane re-inverted, the parts dusted with iodoform, and a carefully graduated compress of antiseptic wool applied with a T-bandage. The parts are bathed each day with some mild antiseptic lotion, and should be healed in ten to fourteen days. The use of the catheter may be necessary for the first forty-eight hours after a severe case, owing to retention of urine. The bowels are not opened until the fourth or fifth day, and then a good dose of castor oil—*e.g.*, 1 ounce in adults—should be administered. It is better to allow the patient to sit on a commode for the evacuation of the bowels. This operation, if efficiently carried out, is absolutely safe and free from danger, and suited to cases where definite hæmorrhoidal tumours are present; any complications from infection, hæmorrhage, etc., are due to the carelessness of the surgeon, and not to the character of the operation.

2. *Ligature* is an operation much in vogue for the treatment of piles, and if carried out with due antiseptic precautions, is followed by a large amount of success. The hæmorrhoidal tumours are grasped by forceps, the mucous membrane divided around them, and the base ligatured with silk; the mass is then snipped off, and the ligature cut short, the knot being allowed to separate by subsequent ulceration. Sometimes it is possible to suture up this wound, and then healing is more expeditiously effected.

3. *Excision* of the individual piles is a very successful procedure, and consists in dividing the mucous membrane longitudinally around the pile, which is then removed, bleeding vessels being secured, and the wound sutured. Perhaps the best way of affecting this is to grasp the pile longitudinally with a pair of Kocher's artery forceps, and then, after cutting away the redundant portion, to introduce a continuous catgut suture, including the forceps and the mucous membrane on either side. The forceps is removed and the suture tightened, thereby preventing bleeding; the wound is effectively sealed, and the bowels may be allowed to act at an early date.

4. Where the hæmorrhoidal condition is general, and both internal and external piles are present, there is no question that *Whitehead's operation* is much the best that can be employed. It consists in the

total removal of this pile-bearing area in the same way as for excision of the rectum. An incision is made round the margin of the anus at the junction of the skin and mucous membrane, exposing thereby the distended veins, which together with the mucous membrane are separated from the underlying sphincter by successive snips of the scissors, and cut away, all bleeding-points being secured. The lower end of the divided mucous membrane is united by suture to the skin, the stitches passing deeply under the surface of the wound, and not merely through the margins. Excellent results follow such treatment in suitable cases.

Rectal Prolapse.—A certain tendency to eversion of the mucous membrane of the bowel is a constant and normal accompaniment of the act of defæcation; if, however, this becomes abnormally increased, the condition may be maintained after the evacuation of the bowels is concluded, constituting a condition of prolapse. At first only the mucous membrane is protruded, and this is known as an *incomplete* prolapse; if, however, the condition persists, the whole thickness of the bowel, mucous membrane, submucosa, and even the muscular and serous coats, may become involved, giving rise to the *complete* variety (Fig. 531). The former condition (sometimes badly termed a prolapsus ani) is more commonly met with in adults, and the latter (the so-called prolapsus recti) in children; but it must be understood that the latter is always preceded by an incomplete stage, limited to the mucous membrane, and that in adults complete prolapse is occasionally observed.

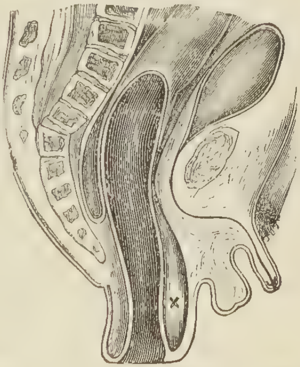


FIG. 531.—LONGITUDINAL SECTION OF COMPLETE PROLAPSUS RECTI. (TILLMANNS.)

x Indicates the serous sac in the anterior wall due to protrusion of the peritoneum.

Causes.—1. It may be produced by a simple relaxation of the tissues, as met with in weakly individuals, and those who have been much exposed to the debilitating effects of residence in tropical climates, especially when chronic constipation or diarrhœa has caused the evacuation of the bowels to be accompanied by straining efforts. In children the malnutrition following measles and whooping cough may predispose, whilst the loss of fat from the peri-rectal cellular tissue may assist. 2. Conditions which have led to chronic tenesmus or violent expulsive efforts—*e.g.*, piles, chronic constipation, diarrhœa, rectal irritation, as from worms in children—or diseases of neighbouring organs, such as vesical calculus, stricture, or enlarged prostate, may also determine prolapse.

Symptoms and Diagnosis.—The anal orifice is occupied by a smooth rounded swelling, red or purplish in colour, covered by mucous membrane; this protrusion in the early stages can be easily replaced by a little pressure, but returns if the patient strains or coughs. When the swelling is of large size, reduction is increasingly difficult and painful from infiltration and fibrous overgrowth of the submucosa, and it is very liable to become inflamed and ulcerated from friction. Incontinence of fæces is also a common result. When the whole thickness of the gut is protruded, the serous lining may accompany the tumour, but this is usually limited to the anterior surface, and into the sac thus formed small intestine or omentum may pass, and even become strangulated (Fig. 531, X). The prolapse itself may also be constricted if allowed to remain for long unreduced; the mass is then livid, swollen, and intensely painful, and if left to itself may slough away, and thus lead to a spontaneous cure, although severe septic symptoms may supervene, and even perforative peritonitis.

There should be but little difficulty in recognising a prolapse; the only condition for which it can be mistaken is an intussusception protruding from the anus; in this, however, the finger or a probe can be inserted into the rectum by the side of the protruding gut, which is impossible with a prolapse.

Treatment.—In the earlier stages, all that is needed is the removal, if possible, of the cause of the tenesmus—*e.g.*, dilatation of a urethral stricture, removal of a vesical calculus—or the regulation of the bowels so as to check either chronic diarrhœa or constipation. When piles are present, they should be treated as described above, and the prolapse will, as a rule, subsequently disappear. Thread-worms must be dealt with by suitable means (*q.v.*). Beyond this, cold or astringent injections may be employed, *e.g.*, sulphate of iron (1 to 3 grains to 1 ounce), and it is advisable for the individual to acquire the habit of having the daily motion at bedtime, whilst children are made to defæcate lying on the side, one buttock being pulled up for the purpose. The prolapse is carefully washed, reduced by pressure with the fingers, and retained by strapping the nates together, particularly in children, or by applying some suitable pad and a T-bandage. Electric treatment to tone up the sphincter and levatores ani may be of assistance, and in children palliative treatment of this type is usually successful.

In adults, however, **Operative Treatment** has frequently to be undertaken.

In the slighter cases of incomplete prolapse, it will suffice to diminish the size of the anal orifice by snipping away radiating folds of skin and mucous membrane, including any piles that may be present. In worse cases it may be advisable to remove a wedge of the posterior wall of the prolapse, including a portion of the sphincter, the edges being brought together by deep stitches. Where this has failed, or is thought insufficient, the prolapse may be completely removed by the following procedure: The patient's buttocks are well raised, so as to prevent any protrusion of intestine if the peritoneal cavity is opened. An incision is made at the junction of the skin and mucous membrane at the anal margin, and is gradually deepened. The base of the prolapse is divided anteriorly on a level with the anus, the opening in the peritoneum temporarily packed with sterilized gauze, and the remainder of the mass removed by scissors, bleeding-points being secured as divided. The serous cavity is then carefully closed by sutures, and the divided end of the bowel united to the skin at the anus. No motion is allowed to pass for a week, but the anal orifice and lower gut should be thoroughly washed out twice or thrice daily to prevent accumulation of septic material. Control over the bowel is usually regained, though often somewhat slowly, and the after-treatment is likely to be prolonged.

The ultimate results are often very disappointing, as the prolapse often recurs after operation, and it is probable that operations of this type should be entirely discarded. The most reasonable proceedings are those directed towards fixation of the rectum (*rectopexy*) either backwards to the posterior pelvic wall, or from above. Various operations of this type have been described and practised, with some measure of success. Thus the posterior wall of the rectum may be exposed by an incision, extending from the tip of the coccyx to the anal margin; if need be, the posterior wall can be infolded in the long axis, and the lumen of the bowel diminished thereby. Stitches are then introduced transversely through the rectal wall (avoiding the mucous membrane), and the ends are passed through the sacrosciatic ligaments on either side and tied firmly over a pad of gauze, being retained *in situ* for three weeks. The rectum is thereby fixed posteriorly, and, with careful after-treatment as to the action of the bowels, good results may follow. As a modification of this procedure, the post-rectal space may be opened up and packed with gauze, thereby determining cicatricial fixation of the bowel.

Abdominal operations in the form of *colopexy* have also been undertaken, the pelvic colon being fixed to the lateral wall of the pelvis by stitches, after stripping away a portion of the parietal peritoneum. The former method of fixation is the more desirable.

Tuberculous Disease of the Rectum occurs in the form of ulcers, which are usually multiple, and may be very extensive. Infection may be due to the swallowing of infected sputum, but is probably the result of dissemination by the blood; the affection is often secondary to pulmonary disease. It starts in the submucosa, and the ulcers which follow have the usual features, with undermined edges and prominent granulations. There is usually a marked tendency to the production of fistulæ by extension of the process outwards. The symptoms are those of rectal irritability, pain on defæcation, and discharge of muco-pus and perhaps blood. **Treatment** is generally palliative, the rectum being emptied by enemata or medicine according to the patient's comfort, and possibly healing ointments introduced. In the worst cases, colostomy may be required in order to put the bowel at rest. Sanatorium and vaccine treatment will probably be required in addition.

Syphilitic Disease of the Rectum and Anus.—The rectum and anus are attacked by syphilitic disease in a variety of ways, the most prominent being as follows:

(*a*) The initial lesion or primary chancre is occasionally met with in the neighbourhood of the anus.

(*b*) In the secondary stage mucous tubercles or condylomata are frequently seen, being placed either at the anal margin or symmetrically on either side, of the gluteal fold, the sores on one side having evidently infected the other. They are of the usual type (p. 159), and are treated by dusting with powdered calomel, and keeping a piece of dressing between the lips of the fold.

(*c*) In the tertiary period *diffuse syphilitic disease of the rectum* is not uncommon, occurring most often, but not solely, in young married women of the poorer classes. It is a somewhat early tertiary manifestation, and usually commences within easy reach of the finger, about 3 inches from the anus. It starts as a diffuse gummatous infiltration of the rectal mucous membrane and submucous tissue, which become thickened and indurated, ulceration soon following. These phenomena are not limited to the rectum, but frequently spread up the intestine towards the sigmoid flexure and down to the anus, and likewise involve the recto-vaginal septum and vagina, passing down the latter canal to invade the perineum and neighbouring structures, so that in a neglected case the whole external genitals and anus may be involved in an irregular hypertrophic mass, somewhat resembling elephantiasis. In addition, the ulcerative process may extend more deeply, leading to the formation of fistulæ, not only between the rectum and neighbouring viscera (*e.g.*, vagina or bladder), but also communicating with the exterior. From the cicatrization occurring in the submucous tissue, contraction of the gut results, causing *syphilitic stricture*, which may extend for some distance up the bowel. The symptoms consist in pain, increased on defæcation, irritability of the bowel, and discharge of blood and pus by the anus, whilst obstructive phenomena, or alternating attacks of constipation and diarrhœa, may also be present. On examination, the diffuse ulceration and infiltration of the part are suggestive of malignant disease, but the patient's age and history, and the painlessness and course of the case, are usually sufficient to determine the diagnosis. The general health remains good in the earlier stages of the affection, but later on may be undermined by the pain and constant purulent discharge.

Treatment consists in administering salvarsan, or mercury and iodide of potassium, the former perhaps in the shape of suppositories, whilst locally contraction is prevented as far as possible by the regular use of bougies. Possibly thiosinamin or iodolysin will be found useful in the later stages to assist in the complete removal of the newly-formed cicatricial tissue. In advanced cases colostomy is essential in order to secure rest to the parts, and give them a chance of healing. Possibly in a few instances only a temporary opening of the bowel may be required, but where much contraction exists and a considerable tendency to obstruction, the artificial opening must remain permanently. Sometimes the ulceration persists in spite of colostomy, and care must then be taken to prevent the retention of discharges by the occasional passage of bougies.

Fibrous Stricture of the Rectum is usually met with in women over forty years of age, and is most often situated 2 or 3 inches from the anus, or as high as its junction with the sigmoid flexure. In this position, it is generally due to the cicatrization and contraction of ulcers following prolonged diarrhœa and dysentery, although occasionally it follows tuberculous or syphilitic disease. Any form of chronic proctitis—*e.g.*, gonorrhœa—may also lead to it. It occurs sometimes as a sequela of pelvic cellulitis and suppuration, from the contraction of fibrous bands which may bind the rectum backwards to the sacral wall, or may merely constrict it; the stricture is in these cases usually at a lower point than in the former. Repeated attacks of inflamed piles may also lead to stenosis at or just above the anus. A stricture sometimes results from traumatism, or follows operations involving the whole or at any rate the greater portion of the circumference of the bowel. As already mentioned, it may be associated with a fistula, especially if the latter has existed for long, and is then due to a chronic inflammatory fibrosis lighted up by the persistent irritation of the stricture; the inner opening is then found in the substance of the stricture.

The earliest **Symptoms** of stricture are often alternating attacks of diarrhœa and constipation, in which, of course, the constipation is primary, and the diarrhœa due to a catarrhal enteritis arising from the irritation of the retained fæces. Gradually the difficulty in passing motions becomes more and more marked until no relief is obtained apart from medicine; the fæces themselves become narrowed, flattened, and elongated, something like pipe-stems, or small masses like shrimps may alone succeed in passing. This is associated with pain and uneasiness referred to the lower bowel; a certain amount of blood and mucus may be mixed with the excreta, and sooner or later marked dyspepsia and abdominal distension supervene. If the case is allowed to run on without treatment, absolute obstruction of a chronic type may result and lead to a fatal issue; or the mucous membrane of the bowel above the stricture becomes ulcerated, an abscess forms, and subsequently a fistula, through which a certain small amount of fæcal material passes. If several of these fistulæ are established, the patient may finally succumb to chronic septic poisoning and exhaustion.

An examination of the bowel with the finger may reveal a smooth, regular constriction of the gut as if a band had been tied round it, the fibrous mass and the aperture in it feeling something like an os uteri. In other cases, the bowel is stenosed for some distance, and its surface more or less ulcerated; whilst if due to pelvic cellulitis, it may be drawn up and fixed to the posterior pelvic wall. When the stricture is too high for the finger to reach, the gut may appear normal, though somewhat dilated (ballooning). Sometimes the stricture is smooth, and free from nodular irregularities and excrescences; often, however, it is ulcerated and irregular, the examination causing great pain. The gut above the contraction is hypertrophied and distended, whilst if filled with retained fæces, the mucous membrane may show signs of inflammation, or even stercoral ulcers. The gut below the stricture is usually dilated (ballooned), partly from paralysis of its walls, and partly by invagination of the mass from above.

The **Treatment** in the early stages consists in keeping the bowels regular and the motions soft by means of paraffin and laxatives, such as castor oil or salines, whilst the passage of the excreta is assisted by enemata. The diet is regulated, so that there is no unnecessary débris. Locally, the stricture, if within reach, should be dilated by means of bougies passed in increasing sizes every two or three days, care being taken that the point of the instrument engages the stricture, and is not caught against folds of mucous membrane or turned backwards. The utmost gentleness must be used, in order to stretch the mucous membrane, and not tear it. Laminaria or compressed sponge-tents are of use in some cases, followed subsequently by bougies. When situated low down, the stricture may be notched posteriorly, or slightly nicked in several places with a blunt-ended bistoury, and bougies then passed. As there is always a great tendency in these strictures to contract again, treatment is usually prolonged. If the stricture is out of reach, or signs of obstruction manifest themselves in spite of treatment, colostomy is the final resource.

Tumours of the Rectum.—**Polypus Recti** occurs most frequently in children, and consists usually of an adenoma of Lieberkühn's follicles, but occasionally of simple fibrous tissue covered with mucous membrane. They are commonly found within easy reach of the anus, and present an appearance something like a small cherry with a long pedicle, pendulous and freely mobile. The **Symptoms** caused are irritability of the bowel and the passage of blood by the anus, which latter when occurring in a child without symptoms of obstruction is almost pathognomonic of polypus. The tenesmus excited may lead, as mentioned elsewhere, to prolapse or to the occurrence of an intussusception. It is occasionally associated with a fissure of the anus, which probably arises as a secondary result of the irritation caused by the partial extrusion of the polypus during defæcation. A natural cure can be effected by rupture of the attenuated pedicle, which is at first attended by a certain amount of hæmorrhage. **Treatment.**—The polypus is cut away after tying or twisting its pedicle, or the clamp and cautery may be employed.

Papilloma of the rectum is a rare disease, and gives rise to hæmorrhage from and irritability of the bowel, or, if large, even to obstruction. This condition is not always limited to the rectum, but may extend through the greater portion of the intestine, and then proves fatal from hæmorrhage. **Treatment** consists in removal by ligature or wire snare, where practicable.

Sarcoma is another uncommon disease in the rectum. It occurs in the shape of a large fleshy tumour growing from the submucous tissue, and projecting into the lumen of the gut so as to cause obstruction. It is less painful than cancer, and usually occurs at an earlier age. The symptoms are much as in the latter disease, and the **treatment,** when feasible, is the same, viz., extirpation of the growth, but it will very probably recur.

Epithelioma of the Anus—*i.e.*, of the skin covering the anal margin—occurs as a primary development similar to that on the lip, and is then of the squamous type. It presents the usual features—viz., an indurated nodular mass, which readily ulcerates, and runs the typical course of such a disease, infecting the inguinal glands. It is readily dealt with in the earlier stages by an operation somewhat similar to that for excision of the rectum.

Cancer of the Rectum appears in the form of columnar carcinoma, consisting, as described elsewhere (p. 224), of an overgrowth of Lieberkühn's follicles, not only into the lumen of the gut (centrifugal or papillomatous type of growth), but also invading the deeper portions of the bowel wall, infiltrating the submucous and muscular layers (centripetal growth). A vascular fibro-cellular stroma is found between the glandular acini, and the physical characters of the tumour are largely dependent on the relative amount of these two elements. Thus, (*a*) if the stroma is abundant and fibro-cicatricial, the growth is comparatively slow; the tumour is hard and nodular; it usually starts on one side of the bowel as a malignant wart-like mass, but gradually encircles the gut, and is always likely to produce obstructive phenomena from its contraction; ulceration occurs after a while. (*b*) In the softer, more rapidly growing type, the stroma is less abundant, and merely fibro-cellular in character. The tumour projects into the bowel, and early involves the whole circumference; ulceration and bleeding are constant features, and the pain is usually considerable. There is always greater destruction of tissue, so that obstruction to the onward passage of fæces is much less likely to occur in it than in the former type, where cicatricial contraction is a marked feature. The ulcer which develops in the bowel is of the usual malignant type, with an excavated surface and raised, indurated, and everted edges (Fig. 532, and Plate XII.); it bleeds readily, and its investigation is very painful. Colloid degeneration is occasionally seen in cancer of the rectum.

As the disease progresses, it invades surrounding parts, and thus the tumour may become adherent either to the pelvic walls or to the bladder, vagina, or prostate; sometimes the iliac vessels or sciatic nerves are compressed, causing œdema or neuralgia respectively. Of course it must be understood that this invasion is in part inflammatory, and due to absorption of bacteria, etc., from the ulcerated surface, and this is always a grave addition to the case. Peri-rectal abscesses and fistulæ sometimes form, opening externally in the ischio-rectal fossæ, or perhaps internally into the bladder or vagina, and then the tumour begins to develop along the line of the fistula, and may actually form a mass of some size in the bladder.

The glands in the meso-rectum and the lumbar glands become enlarged, but for a time this may be merely inflammatory in type, though later on they become cancerous. Anal cancer, of course, leads to involvement of the inguinal glands. Secondary deposits may also be found in the liver, but this is more common when the cancer is higher up the bowel; the disease may even be disseminated throughout the body, though this is decidedly rare.

The **Symptoms** of the disease are often so slight, and the onset so insidious as to raise no suspicions of the existence of any growth until it has attained considerable size. The patient is usually an adult, and more often male than female. At first there may be merely some slight constipation, requiring an increased amount of opening medicine. Then may come more definite attacks of constipation, alternating with diarrhœa, and the discharge of large quantities of mucus, often blood-stained. A sense of weight or dragging pain is noticed in the rectum, and the patient after defæcation feels as if there is still something to be passed. This sensation increases until true tenesmus and straining at stool are present, together with constant pain, which may radiate up the back and down the legs, causing sitting on any hard substance to be painful. At first a blood-stained discharge may be seen on the fæces, which become flattened and pipe-like, if stenosis is present, but later it

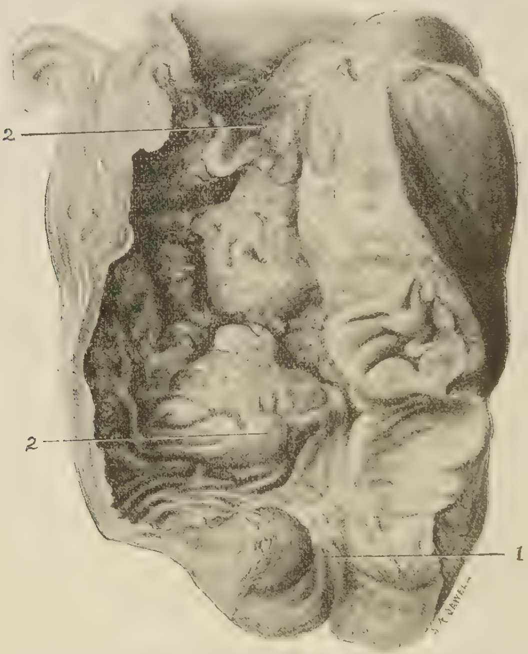
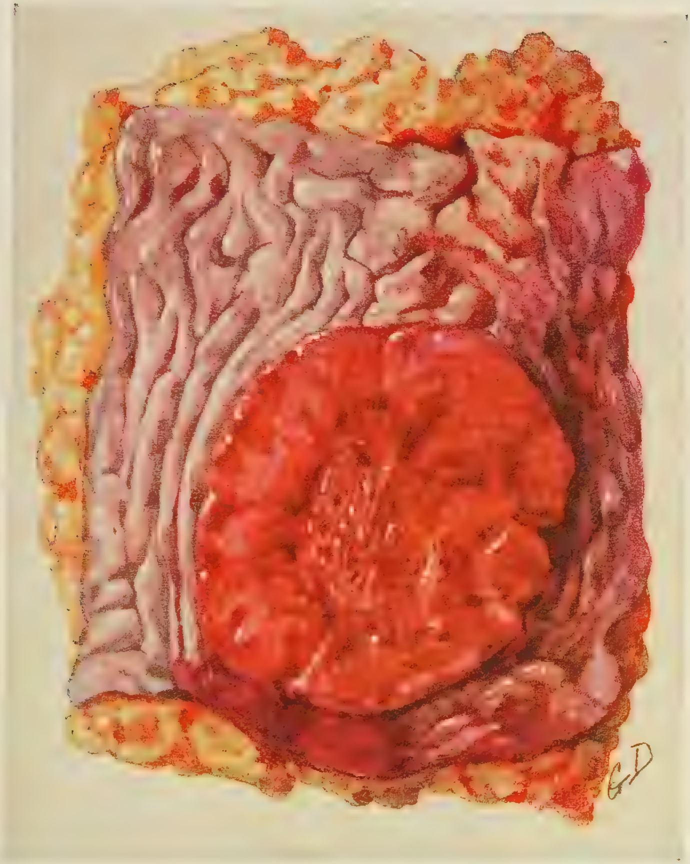


FIG. 532.—CARCINOMA OF THE RECTUM. (KING'S COLLEGE HOSPITAL MUSEUM.)
1, Anus, split open posteriorly; 2, 2, margins of the ulcerated growth.

PLATE XII.



Malignant disease of Rectum.

The growth was an ulcerated columnar carcinoma on the posterior wall, situated about 3 inches from the anus, and had extended nearly round the whole circumference ; it caused much irritability and diarrhœa, and was removed by Kraske's method, without interfering with the anal canal.

[*To face page 1168.*

passes independently of the motions. On examination, an ulcerating, crateriform mass is met with, which may be limited to one segment of the gut wall, and is then usually firm, and perhaps associated with stenosis; or it may surround the bowel, and feel soft and spongy, readily breaking down under the finger, and bleeding freely. The bowel below the growth is usually 'ballooned.' This examination is generally painful, as also the process of defæcation, and sometimes the patient abstains from the latter for lengthened periods on account of the exquisite agony caused thereby. When the anterior wall is involved, the bladder is often fixed to the mass, and micturition becomes painful; moreover, every time the bladder is emptied a discharge may occur from the bowel, and this may continue even after colostomy has been performed. Marked cachexia supervenes, the digestion becomes impaired, any meal causing pain and flatulent distension; natural sleep is impossible, and if a recto-vesical fistula forms, the patient's troubles are further aggravated by the passage of fæces and flatus by the urethra.

The case runs a more or less rapid course to the fatal issue, which on an average ensues about seventeen months after the onset of symptoms, if no operation has been undertaken (Jessop*), and may be due to a variety of causes. Fæcal obstruction occurs in about 30 per cent. of the cases, being more marked in the chronic forms, and in those where the disease starts high up the bowel, on account of the peristalsis causing invagination of the mass and occlusion of the tube; whilst if ulceration is excessive, or the disease situated low down, obstruction is less common, invagination being here impossible, and peristalsis being expended on the onward passage of the fæces. Exhaustion from hæmorrhage, pain, sleeplessness, or toxic absorption, accounts for most of the fatal results, whilst septic peritonitis following the perforation of stercoral ulcers above the growth occurs in a few instances.

The **Treatment** of cancer of the rectum consists in the radical measure of excision of the mass, or in the palliative operation of colostomy.

Excision of the Rectum, or proctectomy, is only applicable to cases in which there is a reasonable prospect of the whole disease being removed. This depends not so much on the upward extent of the growth as on the question of fixation to surrounding parts. When the mass is not fixed anteriorly so as to endanger other viscera (*e.g.*, the prostate or bladder), the case is a favourable one for excision. Fixation of the mass laterally or behind is not so important, although it will prevent removal, if extensive. Enlargement of glands in the meso-rectum does not necessarily contra-indicate operation, as they may be included in the scope of the high operation. When the lumbar glands are involved, or the liver, excision is obviously useless and should not be undertaken. Formerly it was considered of vital importance to avoid opening the peritoneum; but at the present day this is frequently done, and with no untoward result, if due precautions are taken; so that, although the growth may be situated high up, if it is freely moveable, and there is no evidence of secondary deposits, an attempt should be made to take it away. It must be remembered that in the male the peritoneum is reached on the anterior aspect of the gut about 2½ inches from the anus with an undistended bladder, whilst it *may* be pushed up another inch when that viscus is full; in the female the peritoneum is situated about 4 inches from the anus, being reflected to the posterior aspect of the cervix uteri. Posteriorly, the lower 4 or 5 inches of the bowel are uncovered by serous membrane in both sexes.

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* *British Medical Journal*, 1889, ii., p. 407.

Excision of the rectum must include in its scope not only the removal of the growth, but also of a considerable margin of apparently healthy intestinal wall, both above and below, together with the lymphatic vessels and glands draining this area and lying in the hollow of the sacrum. This removal can be effected in several ways, and the choice of operation depends chiefly on the character, position, and extent of the growth, but also to some degree upon the condition of the patient. The actual operations are known as (1) the perineal or Langenbeck's operation; (2) the trans-sacral or Kraske's method; (3) the abdominal; and (4) the combined abdomino-perineal procedure, where the growth is attacked both from above and below.

1. **Perineal Proctectomy,** or **Langenbeck's Operation,** is a satisfactory procedure in cases of early cancer of the lower part of the rectum when the glands in the hollow of the sacrum are not obviously involved. In most cases preliminary colostomy is a desirable procedure, especially if the whole circumference of the bowel for a distance of 3 inches or more has to be removed, and the more so if the anus has to be sacrificed. The passage of fæces over and through the raw surface of the wound is not only a source of septic contamination, but also causes extreme pain, whilst the ultimate issue of the operation is an opening which is almost certain to become unduly patulous or too much contracted, and there is always a total loss of control. An effective anus in the left iliac region obviates all these difficulties, whilst the preliminary opening of the abdomen gives the surgeon an opportunity of investigating the condition of the lumbar and sacral glands, and of ascertaining the extent of the growth up the bowel, and whether or not secondary deposits are present in the liver.

The *Operation* itself is conducted as follows: The rectum having been thoroughly washed out and emptied, and the patient placed in the lithotomy position, the perineum is shaved and purified, and the posterior wall of the rectum and anus slit open in the middle line as far as the tip of the coccyx. An incision is now made all round the anus at the junction of the skin and mucous membrane, if the anus is healthy; when diseased, the incision is extended beyond the margin so as to include the growth. The rectum, together with the tumour, is then separated from surrounding structures by scissors and fingers, commencing posteriorly, where this is readily effected, dividing the levator ani on each side, and working gradually upwards and to the front, where great care must be taken to protect the vagina, prostate, or membranous urethra. In the male, a bougie or catheter may be passed into the urethra with advantage. Bleeding-points can be secured during this process by pressure-forceps. The upper attachments of the gut are divided either by scissors, écraseur, or clamp and cautery. Hæmorrhage, which is generally very free, is arrested by ligature or cautery, and the gaping wound powdered with iodoform, and packed for twenty-four hours with gauze, the posterior incision not being closed by suture, and no attempt made to drag down the mucous membrane. Subsequently the wound may be left without any internal dressing, an external pad of salicylic wool sufficing; it is thoroughly washed out two or three times a day with some dilute antiseptic, such as sanitas (1 in 10), Condy's solution, or carbolic acid lotion (1 in 60), which may be used alternately; granulations gradually cover the surface, and, as cicatrization progresses, the mucous membrane is by degrees approximated to the skin margin, and the patulous cavity diminished in size until healing is complete.

2. The **Trans-sacral or Kraske's Operation** consists in the removal of the growth after a portion of the coccyx or sacrum has been cut away. It may be undertaken in cases where the growth extends upwards from the lower into the upper parts of the rectum, but is more especially suitable to cases in which the anal canal is not involved, and the lower edge of the growth is situated 3 or 4 inches up the bowel.

The question of a preliminary colostomy has again to be considered. In this operation it is desirable that the surgeon should aim at a restoration of the canal, so that the patient shall afterwards pass fæces normally. Whilst admitting that this is not the usual termination of the case, yet it is sometimes obtained, and therefore a colostomy is *prima facie* undesirable. It can always be established at a later date if a sacral anus or fæcal fistula in the sacral region persists and is troublesome. If, however, the patient is previously suffering from obstructive phenomena, and probably has a collection of hard fæcal matter above the growth, a colostomy is essential in order to clear the bowel; it is advisable, however, to make it in such a way that it may be subsequently closed.

Operation.—The patient reclining on his right side, an incision is made in the median line from just behind the anus to the middle of the sacrum, but without opening the bowel. The coccyx is excised, and the great sacro-sciatic ligament and gluteus maximus are detached from the left side of the sacrum. Part of the left wing of the latter bone is now removed by chisel and hammer, the incision being curved, and extending from the median line below, through or above the fourth posterior sacral foramen to the under border of the third, and then to the left border of the bone at that level (Fig. 533, *a b*). The loose cellular tissue behind the rectum is thus exposed, and the gut, together with the tumour and the enlarged glands in the hollow of the sacrum, is freed from its connections, and amputated from the sound gut above, the peritoneum being usually encroached on in this stage of the proceedings. A strip of sterile gauze is packed in to protect the cavity from infection, and the opening is subsequently sutured. If the growth extends to the anus, the whole length of the rectum below is excised, and then the upper segment is drawn down after being mobilized by division of the peritoneum on either side of the meso-rectum, and sutured to the skin. If the sphincter and lower inch or two are free from disease, they are left *in situ*, and carefully sutured to the lower end of the upper segment, although it is very probable that complete union will not occur. The wound is carefully washed out, and stuffed with gauze sprinkled with iodoform; even if the peritoneal sac has been opened, no harm will usually come of it. The results which have followed this severe operation are, on the whole, encouraging. Should partial union of the upper and lower segments occur, and merely a fistula be left, it may be possible to close this by a secondary operation.

Various modifications of Kraske's proceeding have been suggested, one of the best being that performed by Bardenheuer. The sacrum is exposed, sawn across just below the third foramina (Fig. 533, *a c*) and the portion thus detached is totally removed. By this means a much more extensive view is obtained of the pelvic contents, and the scope of the operation increased. In all such procedures the importance of preserving the third sacral nerves which supply the bladder must be kept in mind.

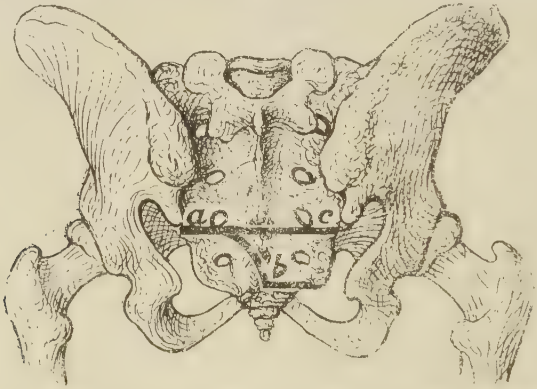

FIG. 533.—PELVIS SEEN FROM BEHIND TO INDICATE THE LINES OF SECTION OF THE SACRUM AND COCCYX IN KRASKE'S OPERATION.

a b, Kraske's original operation; ***a c***, Bardenheuer's modification.

3. The **Abdominal Operation** is only possible when the lower 3 or 4 inches of the bowel are free from disease. Its object is to remove the upper segment of the rectum, part of the pelvic colon, and of the attached mesentery with its lymphatic glands and cellular tissue, and to restore the continuity of the bowel by suturing the ends together from above. The operation is conducted in the Trendelenburg position, and the rectum must be previously thoroughly irrigated with lysol or some other antiseptic. The abdomen is opened in the middle line, and the intestines drawn down out of the way and protected. A full examination of the parts is then feasible, and a final

determination reached as to the character of the operation required. The rectum immediately below the disease is carefully clamped and cut across; the lower segment is temporarily guarded. The peritoneum on either side of the upper segment is now divided, and the tissues of the meso-rectum freed therefrom. A portion of the sigmoid suitable for approximation to the lower end is selected, and by dividing the peritoneum of the meso sigmoid on its outer side the loop is freely mobilized. The gut is clamped above, and the diseased segment removed, the vessels supplying it being secured by ligatures, and this may even include the main branches of the inferior mesenteric artery. The upper and lower segments are then united by sutures, either within the pelvis or by invaginating the two through the anus and performing the anastomosis outside, with subsequent reposition. An effort is made to restore the continuity of the peritoneum by suturing, and it may be wise to insert a large drainage-tube through the anus so as to reach above the line of suture and allow flatus to pass. In weakly patients it is sometimes undesirable to prolong the operation by attempting the restoration of the canal, and in stout patients it may be impossible to effect this owing to the amount of fat present. Under such circumstances it is wise to complete the operation by the formation of a terminal artificial anus in the left iliac fossa, and by closing completely the anal segment of the bowel.

4. The combined **Abdomino-perineal Operation** is chiefly used as an alternative to the perineal or to Kraske's method, and has the great advantage of permitting a wider removal of lymphatic vessels and glands. The abdomen is opened usually through the left rectus, with the patient in the Trendelenburg position. After due examination, the bowel above the growth is divided in a suitable position; the lower end is completely closed, whilst the upper has a Paul's tube tied into it, and is fixed in the wound so as to form a permanent colostomy. The peritoneum of the mesentery of the distal segment is then divided on each side close to its parietal attachment, and the bowel with all the tissues behind it lying in the hollow of the sacrum is peeled downwards to the pelvic floor, care being taken to guard the ureters and main iliac vessels. The peritoneum of Douglas's pouch is then incised transversely, and the separated bowel and the tissues connected with it are pushed down below it, and covered over by suturing together the divided segments of peritoneum. The abdomen may then be closed, and the rest of the operation is conducted in the left lateral position as in the perineal procedure. After the bowel has been removed, the perineal wound may be entirely closed, special care being directed to securing together the divided segments of the levator ani. Whenever possible, it is desirable that this operation should be conducted by two surgeons working together, one from the abdomen, and one from the perineum; much time is thereby saved, and shock is minimized.

Occasionally it is possible to avoid the formation of a colostomy by carrying the lower end of the divided sigmoid flexure downwards, and fixing the lower end in the perineum.

The mortality after all these operations is high, reaching at least to 26 per cent.; this is largely due to the grave risks of infection, and in a less degree to the severity of the procedure. Perhaps the abdominal methods which include the formation of an artificial anus have some advantage by reducing the chances of fæcal contamination. The tendency to recurrence is also considerable, but even should this occur the recurrence is often less painful than the primary disease owing to the previous removal of the nerve terminals.

Excision of the rectum is only practicable in a small percentage of the cases of cancer which come under observation; usually the disease has progressed too far by the time that the patient is first seen by the surgeon. Practitioners and students alike must be warned emphatically of the importance of making a thorough examination of the rectum in all cases where hæmorrhage or discharge occurs, or persistent discomfort is complained of.

As already stated, if the radical operation is not feasible, **Colostomy** is sometimes justifiable as a means of relief to the patient's symptoms. Cases where excision cannot be attempted may be divided into two groups according to the character of the symptoms—*i.e.*, whether obstructive or irritative phenomena predominate.

1. When the main trouble arises from difficulty to the onward passage of the bowel contents, much benefit will be derived from an early colostomy. (*a*) It allows the patient to indulge in solid food, and thus assists in maintaining the general health; (*b*) it frees him from the pain arising from the passage of fæces over the ulcerated surface, but not from that due to the growth and traction of the tumour upon surrounding nerves; (*c*) it may possibly retard the growth of the disease by eliminating the irritating action of the fæces; (*d*) it removes all chance of intestinal obstruction from the growth itself; and (*e*) it diminishes the absolute risk of the operation by undertaking it when the patient is comparatively well and hearty, and when there is no urgency. Formerly, when performed for obstruction alone, the death-rate was about 30 or 40 per cent.; in an early iliac operation it is now practically nil, or at most 3 or 4 per cent.

2. In the *ulcerative* type, where there is but little tendency to stenosis, colostomy will do but little good, as, although it may prevent fæces from irritating the surface of the growth, yet the discharge of muco-pus and blood will continue unchecked, causing tenesmus and constant calls to empty the bowel below the artificial opening. The additional attention required by the colostomy wound may make the patient's life a burden to him.

For details as to colostomy, see p. 1034.

Should the patient refuse colostomy, or should it be contra-indicated, treatment consists in limiting the diet to such materials as strong broths, arrowroot, etc., with some stimulant, so as to give as little fæcal remains as possible, and to enable him to do without an action of the bowels for about a week at a time. The strength is husbanded by keeping him in bed, and pain is checked by the administration of morphia.

CHAPTER XXXIX.

SURGICAL AFFECTIONS OF THE KIDNEYS.

THE kidneys are placed on either side of the middle line, and extend from the eleventh rib above to midway between the last rib and the iliac chest below, the right kidney being somewhat lower than the left, owing to the presence of the liver. The hilum is situated opposite the spinous process of the first lumbar vertebra, and the upper ends of the organs are nearer to the spine than the lower.

The kidneys may be exposed by two chief routes, viz., the lumbar and the abdominal.

The **Lumbar** incision (Fig. 534, B) commences at a point corresponding to the outer border of the erector spinæ, and ½ inch below the last rib, extending downwards and outwards in the direction of the fibres of the external oblique towards the anterior superior iliac spine. The posterior portions of the abdominal muscles and the fascia lumborum are divided *seriatim*, and the fatty tissue surrounding the kidney is thus easily reached and opened. Variations of the incision must be made to suit the particular requirements of the case.

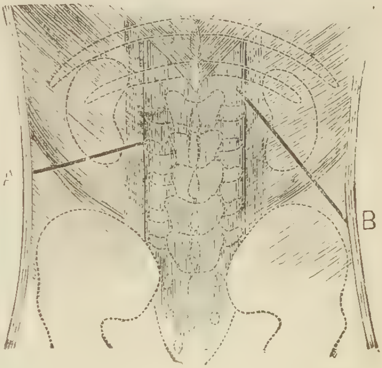

FIG. 534.—DIAGRAM TO ILLUSTRATE LUMBAR INCISIONS.

A, For lumbar colotomy; B, for exposing the kidney.

In the **Abdominal** operation the kidney is exposed from the front, either through the linea semilunaris or some other suitable incision; the peritoneal cavity is opened or not, as may be thought necessary. If the peritoneum is opened, the colon is displaced inwards and held aside, as also the other intestines, by cloths soaked in warm salt solution; the peritoneum covering the posterior abdominal wall is incised to the outer side of the colon, and the organ thus exposed. When, however, the kidney is enlarged, it is often unnecessary to open the peritoneal cavity, the colon and other peritoneal contents being displaced inwards.

Examination of the Kidney and its Function.—1. **Manual** examination of the kidney is made with the patient on the back, with the legs raised, the head supported by a pillow, and the mouth open. The surgeon, kneeling or standing at the side of the couch, places one hand under the loin and presses it upwards, whilst the other is gently but firmly pressed backwards in the lumbar region, especially during expiratory movements. Unnatural mobility, enlargement, or displacement downwards of the organ, will be thereby detected, as also irregularities in outline or modification of tension.

An **enlarged kidney** is recognised by the following general characters: A swelling is noticed in the loin, which is shaped more or less like the kidney, a notch being occasionally, though rarely, felt on the inner border, and the outer margin being rounded. The flank is always dull on percussion, the note remaining unaltered whatever the patient's position, and intestine never finding its way behind the tumour. The passage of the colon in front of the kidney not unfrequently gives rise to a band of resonance over its anterior surface; the bowel, however, soon gets pushed aside inwards by the growth of the tumour. On the right side it is not unusual for the renal dulness to be continuous with that due to the liver; there is always distinct resonance below and to the inner side of the mass towards the pelvis, thereby distinguishing it from a pelvic swelling. The mass moves slightly on respiration, though less distinctly than the liver or spleen.

On the left side it has to be distinguished from an enlarged spleen; the latter viscus hugs the anterior abdominal wall, and has no gut in front of it, whilst the loin is usually resonant.

2. The **Existence and Functional Utility** of a second kidney must be carefully investigated in any case where the removal of a diseased kidney is being considered. (*a*) The only safe test lies in securing a satisfactory specimen of the urine from the second kidney. This can best be effected by *catheterization of the ureters*, which has practically displaced all other methods. The bladder is carefully washed out and disinfected, and after putting 10 ounces of clear water in it, a suitable cystoscope is introduced, with a catheter ready for insertion. Considerable practice is necessary in order to effect this quickly and satisfactorily, but it is a most valuable proceeding. (*b*) *Separators* of various types were employed before ureteral catheterism became common, and of these Luys' instrument (Fig. 535) was the most satisfactory. The bladder is first thoroughly irrigated, and the instrument introduced. The india-rubber septum is then drawn into place, and the urine collected from the two sides as it enters the bladder. To act effectively the curved end must be pressed well backwards against the posterior vesical wall, and the patient must be in the sitting position. (*c*) A small injection of methylene blue (*vide infra*) is given, and the passage of the discoloured urine from the ureter into the bladder watched

by means of the cystoscope. (*d*) It is sometimes necessary to remove a kidney during an operation when a previous thorough examination has not been practicable. In such a case the only safe proceeding is to open the peritoneal cavity and pass the hand across and palpate the opposite organ, not only noticing its size and shape, but also the condition of the pelvis and the renal vessels. Although the organ may be defective in function, the surgeon by observing such a precaution will be preserved from the tragedy of removing the only available kidney.

3. The **Activity of the Renal Function** for both kidneys or for each separately can be estimated by a number of methods, of which, however, one can only give the briefest notice here.* (i.) The *Methylene-blue* test is based on the fact that when a solution of this substance is injected into a muscle, it is absorbed into the blood as a colourless product, but is eliminated both in the bile and urine. In the latter, part of it appears as a blue or bluish-green colouring matter, part as a colourless product (chromogen), which can be made apparent by boiling with acetic acid. If 5 minims of a 10 per cent. solution is injected into a healthy person, chromogen appears in fifteen minutes, and the blue colour in the excretion is at its maximum in four or five hours, remains stationary for a few hours, and then gradually decreases; about half of the methylene blue is eliminated in twenty-four hours, but it is often five or seven days before it disappears entirely. In disease of the kidneys involving

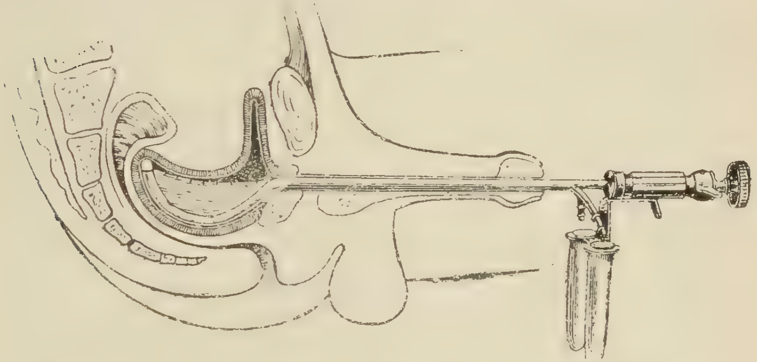

FIG. 535.—LUYS' SÉGREGATOR IN POSITION FOR COLLECTING SEPARATELY THE URINE ESCAPING FROM THE TWO URETERS.

The indiarubber septum can be seen stretching across the bladder cavity, and the curved beak fits down firmly into the 'bas fond' of the bladder, so that the urine will at once pass into the openings on either side of the septum, and so up to the collecting glasses. The screw-head of the instrument controls the septum, which is, of course, only stretched into position after the introduction of the instrument.

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* For fuller details, see Thomson Walker's Hunterian Lectures on 'The Renal Function in Health and Disease,' *Lancet*, March 16 and 23, 1907.

defective function the elimination of this substance is late in appearing and prolonged beyond the normal period. This, of course, can be estimated for each kidney separately by catheterism of the ureters. (ii.) The *Phloridzin test.* If 10 minims of a solution of phloridzin (1 in 200) are injected beneath the skin, sugar appears in the urine of a healthy person in fifteen to twenty minutes, and the glycosuria lasts for two to three hours, the total output of sugar being between 1 and 2·50 grammes. Where the function of the kidneys is defective, the amount eliminated is much diminished, or it may be entirely absent.

Diminution in or loss of the functional activity of the kidneys results in an accumulation of toxic products of varying characters in the blood, which leads sooner or later to the development of a condition of **Uræmia,** which may have a gradual or sudden onset, and be represented by a multiplicity of varying symptoms. Headache, vomiting and convulsions, are probably the most characteristic features, but there are many other suggestive manifestations, such as delirium, various paralyses, asthmatic attacks, etc. In considering the advisability of operating on many renal conditions, the possibility of the development of an acutely fatal attack of uræmia as the result of the anæsthetic must be kept in mind, and a careful examination of the urine made. *In every renal case the daily output of urine and its specific gravity should always be noted* ; a persistent low specific gravity (1010) and a defective urea-content are always danger-signals. The amount of urine passed apart from a knowledge of its specific gravity is no guarantee of the efficiency of the renal secretion.

4. A thorough **Examination of the Urine,** chemical, microscopical, and bacteriological, is essential in all conditions affecting the urinary organs, and particularly in affections of the kidney. In the majority of cases the *chemical test* limits itself to ascertaining whether or not albumen or sugar is present.

Albuminuria, or the escape of some of the albuminous contents of the blood with the urine, is a condition of such frequent occurrence, and so important in its results, that the precaution should always be adopted of testing the urine of every patient before undertaking any operative proceedings; and this is the more essential because it is well known that this condition often exists quite unexpectedly and entirely apart from symptoms.

Tests.—Many different methods have been adopted for detecting the presence of albuminuria. The following are, however, the chief: (1) On simply boiling the urine a milky white deposit forms similar to that which is caused by an excess of phosphates; the latter, however, disappears entirely on the addition of a single drop of dilute acetic acid, whilst the former persists or increases. (2) Nitric acid gives a white cloud or light brown flocculent precipitate. The urine should first be boiled and the acid added, but not in excess, as the deposit may be re-dissolved. A more delicate test consists in pouring the cold urine into a test-tube, and carefully adding the acid so as to form a stratum below the urine; at the line of junction of the two, a white film is formed, if albumen is present. (3) With picric acid a yellowish-white precipitate is thrown down, increased by boiling. If the urine is neutral or alkaline, it must first be rendered slightly acid by the addition of a few drops of acetic acid.

When once the existence of albumen in the urine has been ascertained, its source and its significance must be investigated. A careful microscopical examination of the sediment is made, so as to determine whether casts or pus cells are present. The condition of the peripheral bloodvessels in the limbs and the character of the pulse should be noted, as also the previous history of the patient.

Albuminuria arises from a variety of sources, and its significance necessarily turns on the origin of the affection. (1) When it is associated with long-standing suppuration, as in diseases of bones or joints, it is probably due to lardaceous change in the kidneys. If the urine is of low specific gravity, and light in colour, and with but few casts, only an early stage of the condition is present, and conservative measures directed to the treatment of the primary lesion will probably suffice; if, however, the urine is scanty and of high specific gravity with much albumen and many casts, the affection has probably progressed some way, and radical treatment, such as amputation, should be undertaken to save the patient's life. The surgeon must be careful to prevent any undue absorption of carbolic acid in the operation, as thereby acute nephritis may be lighted up, and even a fatal issue determined. (2) Albuminuria may be intermittent (cyclical), and is then due to some temporary functional disturbance; this can only be ascertained by testing the urine from time to time. In such cases operation is not contra-indicated, the albumen usually disappearing with rest and careful diet. (3) When caused by chronic Bright's disease, the concurrent phenomena of that affection will also be present in the shape of thickened arteries and high pulse tension, whilst possibly a certain amount of anasarca may be noted, or the history of such at an earlier date. If there is but little albumen, and a fair amount of urea is being passed, it is possible by rest and suitable diet so to diminish it as to warrant the performance of slight operations; but where the condition is at all advanced, all *opérations de complaisance* are absolutely contra-indicated, and only the chief surgical emergencies should be knowingly dealt with, viz., hæmorrhage, asphyxia, grave intraperitoneal lesions, and retention of urine. In severe injuries, amputation is generally indicated under circumstances where in a healthy individual conservative measures would be adopted. Operation for malignant disease may be undertaken at the request of the patient if the increased risks have been explained to him. The risk depends on the facts that such patients tolerate an anæsthetic badly, that the tissues are in a condition of lowered vitality, and hence the process of repair is hindered; infective inflammations and erysipelas are very prone to develop, whilst secondary hæmorrhage is predisposed to by the high pulse tension. Again, boils and carbuncles are very common in these patients, and where such conditions are met with, and especially if they recur, the urine should always be examined. (4) Albuminuria may arise by extension of inflammation to the kidneys from surgical affections of the lower urinary organs, and a fatal result from shock or suppression of urine may follow an operation under these conditions. (5) It is sometimes the result of cardiac disease, owing to valvular incompetence and regurgitation into the systemic veins, and it is then advisable to delay all operative measures until suitable treatment has relieved the urgent symptoms.

Glycosuria and **Diabetes** are alike characterized by the presence in the urine of sugar (glucose), but whilst the former may be temporary and of comparatively little significance, the latter is generally permanent and due to disease of the pancreas. The mere existence of sugar in the urine is not nowadays looked on as an absolute contra-indication to operative treatment, as was the case formerly, and yet the urine of all patients requiring operation should always be examined as a routine preliminary in order to ascertain whether or not it is present. The chief tests employed are as follows: (1) Equal parts of liquor potassæ and solution of copper sulphate are boiled together, and then a few drops of the suspected urine added; if sugar is present, a yellowish-red precipitate forms by the reduction of the cupric salt to cuprous oxide. (2) The same result follows the use of Fehling's solution. It is better to keep the copper solution separate from the potash; equal parts of them are boiled together, and a few drops of the urine added; if sugar is present, a red deposit occurs. (3) Picric acid and liquor potassæ are mixed and boiled, and the urine added; the presence of sugar is indicated by the solution turning to a dark, blackish-red colour. The admixture of 2 grains of sugar to the ounce is sufficient to determine this discoloration to such an extent as to render the fluid quite opaque.

Simple Glycosuria arises from many different conditions, included amongst which may be mentioned an excess of carbohydrates and of fatty or sweet things in the dietary, the liver being unable to store them away, hepatic disturbances of various types, and injuries or diseases of the medulla or upper part of the cord. An interesting form of glycosuria occurs in some infective conditions of the type of cellulitis (boils, carbuncles, etc.), where the presence of glucose in the urine appears to be secondary, and disappearance quickly follows effective operative treatment. The explanation of this condition is not at all obvious.

True *diabetes* is now generally considered to be due to lesions of the pancreas. Experimentally, total removal of the gland in animals is followed by diabetes, and in man clinical research has demonstrated that certain types of chronic pancreatitis, in which degeneration or destruction occurs of the curious cellular bodies known as the Islands of Langerhans, are associated with diabetic phenomena. These islands are supposed to form the internal secretion of the gland, a ferment upon the activity of which the glycogenic function of the liver depends. In the vast majority of the accredited cases of diabetes lesions of the pancreas are demonstrable, and the condition is often improved by hydrotherapy and measures directed to relieving hepatic engorgement. It is quite reasonable to consider seriously, in all cases of diabetes, the question of exploring the biliary and pancreatic passages with a view to remove calculi, or relieve congestion by temporary drainage. Although the condition may not be absolutely cured, yet great benefit has frequently resulted.

In simple glycosuria limitation of diet for a few days and rest in bed, with some attention to the activity of the liver and of the bowels, will frequently cause a diminution in the excretion of sugar, and under such circumstances a surgeon need not hesitate to perform ordinary operations. But if the sugar persists in spite of such treatment, and there is reason to suspect that the case is one of true pancreatic diabetes, operations must be undertaken very cautiously. The tissues are always in a condition of lowered vitality, so that infection readily occurs, as indicated by the frequency of such conditions as boils, carbuncles, and infective gangrene of the extremities. In old-standing cases, peripheral neuritis and sclerosis of the smaller vessels are induced, and gangrene is not an uncommon sequela (p. 117). It is therefore obvious that operative proceedings should not be resorted to unless they are absolutely necessary; but, unless the case has progressed very far, there is no reason why necessary operations should not be performed, granted that the most rigid care is taken as to the maintenance of asepsis. Thus several cases have been reported in which such serious proceedings as total removal of the breast and axillary contents for scirrhus, or appendicectomy, have been safely undertaken in confirmed diabetics.

One of the chief dangers of neglected or serious diabetes is the supervention of **Diabetic Coma,** which may develop without apparent reason, or be lighted up by some septic complication, or the operative treatment required for the same, especially if a general anæsthetic is given. The patient becomes apathetic, and finally dies in a condition of coma; his breath smells of acetone, and the blood is defective in its alkalinity. The explanation of this is as follows: in diabetes there is always an excessive production of acid in the body—mainly β-oxybutyric acid—which in health is either not formed, or is oxidized to CO_2 and H_2O. In this disease it is excreted in combination with alkalies, mainly with the ammonium which is normally formed into and removed from the body as urea. The sodium and potassium of the blood are also called on to neutralize it, and even calcium or magnesium may be dissolved from the bones. The blood therefore suffers in its alkalinity; the carbonic acid is no longer carried to the lungs, and consequently dyspnœa, with or without cyanosis, may result. Diacetic acid is also formed, especially just before coma occurs. It arises by oxidation of the β-oxybutyric acid, and breaks up in its turn into acetone and carbolic acid. Its presence can be demonstrated in the urine by the addition of ferric chloride, when a claret colour appears; if the urine is subsequently boiled, this discoloration disappears (p. 1346). Naturally the presence of this acid in the urine of a diabetic patient is a danger signal, warning the surgeon that coma is not far distant, and that general anæsthetics must be avoided. Large doses of sodium bicarbonate given by mouth or rectum, or even by intravenous infusion, may be of use in checking the progress of this condition.

For the influence of diabetes and albuminuria in the choice of an anæsthetic, see pp. 1345 and 1354.

Hæmaturia, or the admixture of blood with the urine, is a frequent symptom in diseases of any part of the urinary track, and it is sometimes a little difficult to ascertain the exact source from which the blood is derived.

(*a*) *Renal* hæmaturia results from acute inflammation, congestion, calculus, tumours, or injuries of the kidney. The urine is sometimes deeply coloured with the blood, and may be as dark as porter. Blood-casts of the renal tubules are often observed, and even long sinuous clots, corresponding to the shape of the ureter.

(*b*) Vesical hæmaturia is due to injury, calculus, tumours, ulceration, simple congestion of the bladder with varicosity of the vesical veins, or the presence of the *Bilharzia hæmatobia*. The blood is intimately mixed with the urine, but is more abundant at the end of micturition, and clots are often present.

The *Bilharzia* is a parasite which inhabits some of the rivers and pools of South Africa. It is taken into the system by the mouth, and may develop either in the urinary track, or sometimes in the lower bowel (p. 1148). The adult worms are found in the body inhabiting the radicals of the portal and vesical veins, and discharge their ova through the mucous membrane of the bowel or bladder, giving rise to hæmorrhage. By an extension to the kidney, pyonephrosis may be induced. No specific treatment has at present been discovered, but in most cases the disease after a time disappears spontaneously. Microscopic examination reveals the presence in the urine of the characteristic ova—ovoid bodies with a terminal spike.

(*c*) *Prostatic* hæmaturia may be caused by congestion, calculus, ulceration, or malignant disease, or especially by the passage of a catheter or bougie used in the diagnosis or treatment of any of these conditions. The blood may pass back into the bladder, and hence the phenomena simulate the vesical condition, but frequently it escapes from the urethra, particularly if due to traumatism. Examination of the prostate from the rectum may, however, give a clue to the source of the mischief.

(*d*) *Urethral* hæmaturia arises from acute gonorrhœa, laceration, or instrumentation. The blood often flows from the urethra independently of micturition, whilst the first few drops of the stream are also coloured.

(*e*) Hæmaturia is occasionally of *constitutional* origin, arising from purpura, scurvy, or hæmophilia; other manifestations of these diseases will be observed, and render the diagnosis evident.

Microscopical examination of the urine should always be made to ascertain whether or not blood-corpuscles are present, since the condition may be simulated by that known as 'paroxysmal hæmoglobinuria,' in which corpuscles are absent. The latter condition is supposed to be due to vaso-motor spasm of the renal arterioles, and is not uncommonly associated with Raynaud's disease.

The only certain **test** for the presence of blood is by spectrum analysis; but that most usually relied on consists in mixing together equal parts of tincture of guaiacum and ozonic ether. The suspected urine is subsequently added, and sinks to the bottom of the test-glass; a copious precipitate forms at the line of junction of the two fluids, which on standing becomes a bright blue colour if blood is present.

The investigation of a case of hæmaturia in order to ascertain its origin should be conducted in the following way: (*a*) The history of the patient and of his urinary trouble should be taken. (*b*) The character of the urine should be investigated, noting its colour, and whether or not the blood is intimately mixed with it. (*c*) The relation of the passage of the blood to the act of micturition should be noted by making the patient pass the first and last portions of the urine into separate vessels from that in which he passes the bulk; if the urine in all three vessels is equally discoloured, the hæmorrhage usually comes from the kidneys; if most of the blood is in the first vessel, it comes from the urethra or prostate, whilst if the bulk of it is contained in the last vessel, it is probably derived from the bladder. (*d*) Microscopical examination of the urine may lead to the discovery of shreds of tumour, epithelial cells, or blood-casts, which could be alone derived from some special part of the urinary track. By these means the source of the hæmorrhage, whether from kidney, bladder, prostate, or urethra, may be detected, and an opinion formed as to the nature of the disease.

Pyuria is the term applied to the admixture of pus or muco-pus with the urine. It always results from inflammatory affections of the mucous membrane lining the urinary passages, and may be renal, vesical, prostatic, or urethral in origin; the methods of investigation, in order to ascertain its exact source, are the same as for hæmaturia.

Pus in urine is mainly recognised by the microscope, whilst on the addition of liquor potassæ it becomes ropy.

Chyluria arises from distension or rupture of the lymphatic vessels in the vesical mucous membrane, and is usually due to the presence of the *Filaria sanguinis hominis* (p. 361). The urine is milky in colour, and on microscopical examination this is found to be due to the presence of an emulsion of fat.

Urinary Deposits of various kinds are of frequent occurrence, and require for their investigation both chemical and microscopic examination. *Uric* or *lithic acid* is eliminated in the form of 'cayenne-pepper' granules, usually known as gravel. On microscopic examination, the granules are found to consist of flat rhomboidal, lozenge-shaped plates, or masses of acicular crystals

(Fig. 536). They are of a dusky brownish-red colour, due to the absorption of urobilin, the normal pigment of the urine. The secretion in these cases is always acid, and usually of high specific gravity. The deposit is not soluble in boiling water, but readily so in alkaline fluids; and on re-acidulating such a solution, the uric acid is precipitated in the shape of white needle-shaped crystals.

Urates or *lithates* of potassium, sodium, or ammonium are of frequent occurrence in the urine, appearing as a deposit of amorphous granules of variable colour, according to the amount of urinary pigment present, and this is often known as a 'lateritious,' or brick-dust sediment. The ammonium salt is sometimes found in the shape of spiculated globular bodies (Fig. 537). Urates always occur in acid urine of high specific gravity, and are freely soluble in boiling water; on the addition of dilute hydrochloric acid the uric acid is precipitated. The *murexide* test may be applied for either uric acid or its salts; it consists in mixing the substance to be tested with a little nitric acid, and evaporating to dryness, when an orange-red discolouration is produced, which on the addition of liquor ammoniæ changes to a deep purple-red.

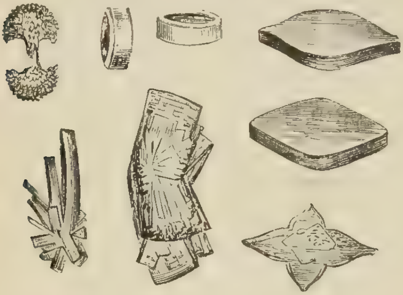

FIG. 536.—URIC ACID CRYSTALS.

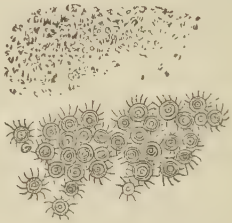

FIG. 537.—URATE OF AMMONIUM IN AMORPHOUS GRANULES AND HEDGEHOG-SHAPED BODIES.

A deposit of uric acid or urates is either a temporary condition dependent on some trivial derangement of the system, or a phenomenon constantly recurring and due to too great an indulgence in nitrogenous food, too little fresh air and exercise, or imperfect digestion, the result of some hepatic disturbance. It is also noted in conditions where great tissue change is occurring, as after violent exercise or in fevers. Under these circumstances the materials which should be changed into urea are transformed into uric acid or its salts. When such a tendency is continually present, the patient is said to be suffering from **Lithiasis** or **Lithæmia.** Should the material thus formed not be eliminated, an attack of gout is likely to supervene, whilst it must always be borne in mind that the formation of a uric acid calculus is merely a manifestation of the same diathesis, which needs careful treatment after the removal of the stone, if a recurrence is to be prevented.

The **Treatment** of lithæmia or lithiasis consists mainly in attention to the personal hygiene. The patient's diet is regulated, all sweets, pastry, and alcoholic stimulants (with the exception, perhaps, of a little whisky well diluted with lithia or potash water) being avoided. Fish and poultry are permitted, but butcher's meat is forbidden. Regular habits are enforced, and plenty of outdoor exercise recommended. The hepatic secretion is stimulated, and the bowels regulated by the administration of saline purgatives, especially natural mineral waters (*e.g.*, Friedrichshall, Carlsbad, or Hunyadi Janos), whilst an occasional dose of blue pill or podophyllin is advisable. Lithia salts and piperazine have also been employed with advantage. A course of treatment at a recognised spa is most useful in these cases.

Oxalate of lime usually occurs in the urine of dyspeptic and hypochondriacal patients, who are pale, nervous, and irritable. It is supposed to arise from the incomplete oxidation of carbohydrate foods. The urine is of low specific gravity, pale and abundant in quantity, and slightly acid in reaction; an excess of mucus is usually present. causing the crystals to adhere to any irregularities in a test-glass. On microscopic examination they are found to be regular octahedra, or in the shape of dumb-bells (Fig. 537A). The *treatment* of oxaluria consists in regulation of the diet, which must be light and nourishing, all heavy food being avoided, as also rhubarb, which contains large quantities of oxalates, and the patient is directed to drink only boiled or distilled water. Tonics, such as mineral acids, iron, and quinine, may be ordered, but the best treatment consists in change of air and removal, if possible, from causes of anxiety and worry.

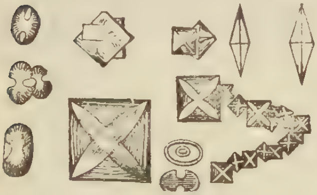

FIG. 537A.—OXALATE OF LIME IN OCTAHEDRAL CRYSTALS AND DUMB-BELL-SHAPED MASSES.

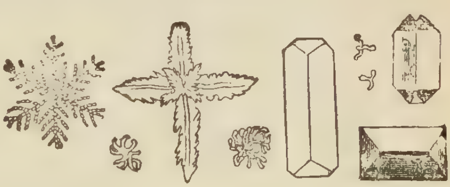

FIG. 538.—CRYSTALS OF TRIPLE PHOSPHATE IN URINE.

Phosphatic deposits in the urine occur in three forms: (i.) The triple, or ammonio-magnesic, phosphate is found in alkaline or decomposing urine, and is always vesical in origin. It exists in the form of hexagonal prisms, three of the sides, however, being very narrow; the ends also are bevelled off, so that the appearance of a 'knife-rest' is produced (Fig. 538). (ii.) The amorphous phosphate of lime is exceedingly common, forming the main mass of any phosphatic sediment. It is always present in chronic cystitis, and is not unfrequently met with a few hours after a meal, constituting what is known as the 'alkaline tide.' This condition is often observed about twelve o'clock in the morning, especially if an alkaline saline purgative has been taken before breakfast. The phosphatic material is voided at the end of the act of micturition, and may give rise to considerable anxiety on the part of the patient, who mistakes it for seminal fluid. (iii.) The most usual condition in which phosphates are met with in urine is a mixture of the two varieties described above. Whichever form is present, the deposit becomes more evident on boiling, disappearing, however, on the addition of a few drops of acetic acid. The treatment of phosphaturia is always directed to the vesical condition, except in those unusual cases where it is due to some constitutional error.

A **bacteriological examination** of the urine has often to be made in order to make sure of the diagnosis of a case. Bacteria may find their way into the urinary passages through the kidneys, or gain an entrance to the bladder *per urethram*, and thence spread up the ureters, or may obtain a foothold in some part of the walls of the urinary track and thence become disseminated. Sometimes they are present in great abundance, and render the urine opalescent to the naked eye (**bacilluria**), but have little or no effect upon the lining walls. Care in diagnosis must be taken to ensure that the sample examined has not been contaminated by passage through the external organs; this is especially needful in women, and, indeed, no bacteriological examination of the urine of a woman is of any value which has not been secured by aseptic catheterism. Bacilluria is a condition of frequent occurrence in women, and the *Bacillus coli* is the organism most often present. In some conditions the number of bacteria present is so small that they can only be found on a careful search after straining the centrifugalized deposit from the urine—*e.g.*, the *B. tuberculosis* in various tuberculous affections of the kidney or bladder; it is sometimes impossible to find them microscopically, and then inoculation experiments with the deposit must be undertaken.

5. Finally, a **radiographic examination** of the kidneys and ureters is often necessary in order to ascertain whether anything in the form of a calculus is present. The use of a soft tube will often enable the lower pole of a normal kidney to be detected; still more obvious does the same part of an abnormally enlarged organ appear, especially if the seat of chronic inflammatory trouble or of a malignant tumour.

There is now not much difficulty in making certain of the presence or absence of a *stone* in the kidney or ureter, although the permeability to the rays of a pure uric acid calculus still renders mistakes possible. A large stone of this character held in the hand in front of the screen cast no shadow deeper than the muscles of the thenar eminence. Oxalate calculi, or those formed of phosphates, cystine, or of a mixed composition, ought in all cases to be demonstrable, and their number, site, and position ascertainable.

The differential diagnosis of the shadows of calculi from those produced by other conditions which may appear on the plates has been rendered easier by the more perfect detail which can now be obtained in the radiogram. In most cases it is possible to show the outline of the kidney, as well as the stones contained in it (Fig. 542), and one can thus eliminate the shadows produced by calcified mesenteric glands, bowel contents, or appendicular concretions (Fig. 495). Gall-stones as a rule cast no shadow, but occasionally some abnormal change in the gall-stone makes it visible, and this may lead to a mistake in diagnosis.

The positive diagnosis of ureteral calculi (Fig. 543) is sometimes more difficult, as they have to be distinguished from phleboliths, calcified pelvic glands, appendicular concretions, bowel contents, calcified appendices epiploicæ, and calcified uterine fibroids, whether pedunculated or sessile. It may be necessary to pass an opaque bougie up the ureter and repeat the examination before a diagnosis can be made. Pelvic glands are nearly always circular and frequently multiple, although it is not uncommon to find a single calcified gland opposite and internal to the ilio-pectineal eminence on one or both sides. Calcified inguinal glands are easily recognised by their superficial position on stereoscopic examination. Bowel contents are excluded by repeating the examination after effective purgation, and, indeed, this is a course which should always be followed except in cases which are absolutely characteristic. Calcified fibroids simulating ureteral or vesical calculi can generally be detected on clinical examination.

The details of radiographic methods for ensuring good results cannot be entered into here, as they are too specifically technical; but one may note that the first essential to success is the effective preparation of the patient, and the second complete immobilization of the area of examination. A general view, including both loins and the upper ureteral regions, should first be taken, and subsequently the affected side should be more carefully examined through some form of diaphragm to limit the diffusion of the rays.

The preparation of the patient for the examination is of great importance, especially in one of heavy build. The intestine must be empty in order to get good results, and the patient should, if possible, be kept on light diet for some days previously. A course of purgation for two or three days, followed by a long-tube enema on the morning of the examination before the patient has had any food, is the ideal preparation.

In addition to calculi, the X-rays are capable of demonstrating the existence of calcified caseous deposits in old-standing tuberculous kidneys, and by injecting some 10 per cent. collargol up the ureter through an ureteral catheter, and subsequently X-raying the side, it is possible to demonstrate the size and shape of the pelvis of the kidney.

Congenital Affections of the Kidney.—Many different malformations and displacements are met with affecting this organ.

The chief **Malformations** are as follows: (1) Complete absence of one organ, a very rare condition. (2) Congenital atrophy of one kidney, it being represented by a mass of fatty tissue. In both cases the other kidney is correspondingly enlarged and hypertrophied. (3) The kidneys may be fused together, either forming one large organ in the median line and more or less normal in shape, or sometimes constituting the so-called **horseshoe kidney,** the convexity being directed downwards. The latter condition is not very uncommon, being present once in about 1,100 bodies examined; it is usually associated with an increased number of ureters or renal vessels. (4) Deep lobulation of the kidney, as in some animals, is occasionally seen, especially if the organ is displaced; this may be carried to such an extent as to divide it into two or more portions. (5) The ureter and pelvis may be double, this malformation affecting the pelvis alone, or extending as far as the bladder. (6) The renal artery may arise from the aorta in two or more main branches.

The majority of these malformations are of very little clinical importance, except in the operation of nephrectomy, when they may necessitate some modification of the usual proceedings.

Congenital Displacement of the Kidney occurs about once in every thousand individuals, the organ being either depressed, so as to lie over the sacro-iliac synchondrosis or sacral promontory, or raised above its normal position. The left kidney is more frequently affected in this way than the right, and, when lying in the iliac fossa, the descending colon is usually displaced inwards, so that the rectum starts to the right of the middle line. The adrenal bodies retain their normal position, and do not move with the kidney.

Cystic disease, sarcoma, and hydronephrosis may also occur congenitally, and will in turn be described below.

Floating and Moveable Kidney.—The normal kidney is not a fixed organ, but moves up and down on respiration, although usually this movement cannot be detected on palpation. It is therefore necessary to define as precisely as possible what is meant clinically by the terms ‘ moveable ’ and ‘ floating ’ kidney. Three stages of abnormal mobility may be described: (i.) A *palpable* kidney is one the lower half or more of which can be definitely felt on deep inspiration. (ii.) A *moveable* kidney is one in which the examining hand can define the upper end of the organ, and can restrain it from returning to its old position during expiration. (iii.) A *floating* kidney is one which can be moved freely about the abdomen in all directions, and even across the middle line in some cases. Formerly this last term was applied to a supposed congenital lesion, in which the kidney was attached to the posterior abdominal wall by means of a mesentery; it is more than doubtful whether such a condition exists.

In the earlier stages the movements occur within the fatty capsule which surrounds the organ, but later on mild attacks of inflammation attach the fatty to the fibrous capsule, and the kidney with its associated fatty envelope moves behind the peritoneum. Two forms of movement are possible: (i.) An up-and-down or in-and-out movement in one plane (*cinder-sifting* movement), the kidney merely swinging on its pedicle; or (ii.) a movement of torsion may accompany this, either round a transverse axis when the lower end of the kidney becomes prominent, or round a vertical axis when the outer convex border swings forwards. In the latter case kinking of the ureter or renal vessels is very likely to ensue.

Moveable kidney occurs more frequently in women than in men (10 to 1), and more often on the right than on the left side (12 or 13 to 1), partly because the renal vessels are longer on this side than on the other, and partly because the descending colon is more fixed than the ascending.

Causes.—The kidney is placed between the layers of the perinephric fascia, which in turn are derived from a splitting of the fascia transversalis. In children this perinephric capsule is attached closely to the kidney front and back without any intervening fat; but as development proceeds, fat is packed in around the kidney in increasing amount, and hence in stout subjects the perinephric capsule is considerably distended, and the kidney is firmly supported. In addition to this, however, the tension of the peritoneum, the maintenance of the intra-abdominal pressure, and the support of the muscular abdominal parietes, have much to do in keeping it in place. Anything that seriously modifies these three factors may lead to displacement and mobility of the organ. Parturition accounts for some cases; firstly, because of the sudden diminution of the intra-abdominal pressure, and, secondly, owing to the resulting pendulous and relaxed state of the abdominal muscles, especially if the patient too early resumes the erect posture, or undertakes physical work without efficient external support; hence it is more frequent among the poor than amongst the rich. It may also follow the removal of large abdominal tumours which stretch the abdominal walls, or rapid emaciation, whereby the perinephric fat is absorbed, whilst tight-lacing or traumatic influences may be responsible for some cases. It is frequently associated with that form of displacement downwards of the abdominal viscera which is known as Glenard's disease, or enteroptosis (p. 1028). Constipation is an important element in the production of moveable kidney, and probably acts by the loaded cæcum dragging upon the anterior layers of the perinephric fascia, and thus displacing it forwards.

Symptoms.—A moveable kidney is often discovered by accident, and may be entirely free from symptoms. In some cases the patient comes under observation because she has observed a moveable lump in the abdomen, which on handling is painful, the pain being often associated with nausea and vomiting. In other cases, pain and vomiting bring the patient under observation, the doctor discovering the moveable kidney. The pain is referred to the back, or perhaps shoots along the ureter to the groin, testis, or labium majus. Vomiting is a significant sign, and the surgeon should never omit t examine the loins in cases of obstinate vomiting with no apparent cause. Periodical exacerbations of these symptoms, with a temporary diminution in the amount of urine, result from kinking of the ureter (*Dietl's crises*); sudden relief, followed by an increased flow of urine, possibly containing some muco-pus, indicates that the organ has returned to its normal situation. Repeated attacks of this type may result in pyelitis and hydronephrosis. On examining the abdomen, a moveable tumour can often be observed with ease if the abdominal parietes are not loaded with fat, and on manipulation pain and vomiting may be induced. The adoption of the genu-pectoral position will sometimes enable a moveable kidney to be more certainly felt, whilst a distinct loss of resistance is noticed external to the erector spinæ on the affected side.

The patient is usually of a neurotic type, but possibly this may result in part from the mobility of the organ which necessarily involves a certain amount of traction upon the sympathetic centres in the abdomen. Evidence of the displacement of other abdominal viscera is often found, so that the detection of a moveable kidney does not necessarily explain the whole case, or indicate operation. After many an operation for moveable kidney, the symptoms (pain, vomiting, etc.) have persisted, even though the organ remained anchored to the abdominal wall.

Treatment.—In the great majority of cases of moveable kidney operation is not required, and, indeed, it is usually unwise to tell the patient that such a condition is present. If it is associated with marked debility, bodily or nervous, and perhaps with general enteroptosis, a rest-cure in bed for six weeks, with abdominal and general massage and an abundance of milk and fatty foods, will do much to steady the kidney and improve the general condition. The application of a carefully-fitted kidney support will then suffice to keep her comfortable. This may consist of an abdominal truss, with an end shaped like a cup to fit over the kidney, or of an air-cushion fitted into an abdominal belt. The cushion should be triangular in shape, its sides corresponding to the costal border, Poupart's ligament, and the linea semilunaris; it is put on in the recumbent posture, and for choice with the pelvis raised.

The indications for operation are—(1) Extreme mobility, so that the organ cannot be fixed by a support; (2) extreme tenderness, so that a support cannot be tolerated; (3) the recurrence of acute attacks of pain and vomiting (Dietl's crises); (4) persistent discomfort in the loin, combined with dyspeptic symptoms, vomiting, and a great variety of neurasthenic manifestations: as a rule a kidney sufficiently mobile to produce such symptoms is tender to the touch, and examination causes pain and nausea; and (5) the supervention of hydronephrosis or pyelitis.

Nephrorrhaphy or *Nephropexy* is the name applied to the operation for fixing the kidney. It is obvious that a rounded body like the kidney with a smooth fibrous capsule is not easily fixed, and the more so since the renal parenchyma has great absorbent power, so that sutures, even of silk, passed through its substance are readily disintegrated and absorbed; hence, although the kidney may seem to be efficiently immobilized at the completion of the operation, it readily becomes loose again. There are only two certain methods of fixing the organ. (i.) The wound down to the kidney is left open and packed with gauze, so that healing occurs by granulation; the cure is certain, but tedious, and a lumbar hernia may follow. (ii.) The plan now usually adopted is to expose the organ through the loin. The fatty covering is opened, and as much of it as possible removed. A portion of the true fibrous capsule is now dissected up and fixed to the abdominal parietes so as to expose the raw and slightly bleeding cortex. Many methods of dealing with the capsule have been suggested, but it matters little which is employed. The following plan suggested by Mr. W. Billington, of Birmingham,* has been extensively tested, and gives excellent results. A lateral incision is employed, extending from just above the last rib almost vertically down to the crista ilii; the muscles are divided; the last dorsal nerve is retracted and protected; and the kidney in its fatty capsule exposed and cleared. The upper half of the fibrous capsule is then dissected up from the posterior surface and carried round the last rib to serve as a sling to the kidney; the apex of this flap is secured to its own base. Two silkworm-gut stitches are passed under the capsule of the lower half of the organ in a semicircular fashion, and carried through the muscles and skin at the upper angle of the incision, being finally tied over a pad of gauze and retained *in situ* for three weeks. The wound is then closed in the usual way, and dressed, special care being taken to exercise pressure over the right iliac fossa below the kidney by a suitable pad of sterilized wool. The organ is thus firmly fixed, but it is wise to keep the patient in bed for four or five weeks subsequently, to allow of consolidation, and afterwards a binder or belt should be worn for a time.

Injuries of the Kidney are usually due to crushes of the body, as between the buffers of railway cars, or when a cart passes over the abdomen, or from blows or falls. Considerable hæmorrhage follows, both into the substance of the kidney or its pelvis, and into the perinephric fatty tissue, and this even when the capsule has not been torn. The integrity of this structure is a point of great importance, since it limits to some extent the bleeding and prevents urinary extravasation; the kidney may be crushed to a pulp without any external hæmorrhage, and under these circumstances clots are likely to pass down the ureter, and may obstruct it and lead to its subsequent occlusion. When the anterior portion of the capsule is torn, the peritoneum may also be involved, especially in children, and then evidences of intraperitoneal bleeding may manifest themselves, and, indeed, if the kidney is extensively lacerated, fatal hæmorrhage may result, though this is unusual. Rupture of the posterior surface of the kidney opens up the perinephric cellular tissue, which becomes infiltrated with blood and urine, and suppuration is almost certain to follow, resulting in pyæmia, or at a later date in exhaustion from chronic septic poisoning. Not unfrequently other severe injuries are present, such as fracture of the pelvis, spine, or skull, bruising or tearing of intestine or liver, and from these associated lesions serious phenomena may arise.

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* *British Medical Journal*, November 30, 1907.

The **Symptoms** consist in severe shock, followed by nausea, vomiting, pain in the loin, shooting down into the testis or thigh, localized tenderness and perhaps swelling over the injured organ, and hæmaturia. The amount of blood lost in this way varies considerably; in the slighter cases the hæmaturia is of short duration, but in more extensive lesions it may be severe and so persistent as to threaten life. The passage of clots down the ureter gives rise to renal colic, and obstruction of that duct may lead to total suppression of the secretion on the affected side. The bladder may in some cases become greatly distended with clots, the blood coagulating after it has entered the viscus. Hæmorrhage into the perinephric tissues is indicated by the formation of a swelling in the loin, and laceration of the peritoneum is followed by distension of the abdomen, increasing anæmia from persisting hæmorrhage, and the onset of peritonitis. The development of a perinephritic abscess is recognised by fever, rigors, increased pain in the loin, and the usual phenomena of deep suppuration (p. 1200).

The **Treatment** usually required is to keep the patient quiet in bed, with an icebag or Leiter's tubes applied to the loin; pain may be relieved by strapping the side or by applying a firm bandage. Persistent hæmorrhage necessitates the administration of ergot, tannic acid, or turpentine; but if it is threatening the patient's life, an exploratory incision is required, and, if need be, removal of the organ, although it is sometimes possible to stitch up a limited rent, the sutures being passed deeply through the glandular tissue. Sometimes the blood does not escape externally, and then the rapid development of a swelling in the loin, with increasing anæmia and rapidity of pulse-rate, would indicate that operation is desirable. Distension of the bladder must be relieved, the clots being washed out through a large-eyed catheter. The occurrence of peritonitis or of a perinephritic abscess will call for suitable surgical measures, the injured viscus being dealt with according to its condition.

Rupture of the Ureter is a rare accident, usually due to direct violence, but occasionally happening during pelvic operations, such as removal of the uterus. When the result of a subcutaneous injury, it cannot be recognised at once, but extravasation of urine takes place, leading to the formation of a perinephritic abscess. This is incised sooner or later, and on exploring the cavity it may be possible to detect the rent in the ureter, but more frequently its situation cannot be found, and then a doubt will necessarily exist as to whether the lesion involves the ureter or the pelvis of the kidney. In either case a urinary fistula in the loin results, which may possibly close after a time; if the fistula persists, nephrectomy will be required, and then the sooner such an operation is undertaken the better. In a few favourable cases it has been possible to suture the rent in the ureter by the following plan: The lower end of the divided ureter is closed, the exposed mucous membrane being tucked in by sutures passing through the muscular coat; the upper end is then implanted into a longitudinal opening made in the side of the lower segment, and accurately stitched in position.

Two cases probably of this nature came under treatment at hospital. Both occurred in young boys, and both were due to cab accidents. In the first, after the preliminary shock had passed off, nothing special was noted for about ten days, when on sitting up sharp pain was experienced in the side, and this was followed by a retroperitoneal collection of fluid, together with some amount of fever. On incision a large quantity of limpid urine escaped, with but very little pus—an interesting illustration of the fact that healthy urine does comparatively little damage to tissues into which it is extravasated. The finger introduced into the wound passed beyond the middle line, and the ureter could be felt traversing the cavity; but the rent could not be found. Drainage was provided, and for a time a urinary fistula persisted; finally, the wound healed completely. In the second case the inflammatory phenomena were more marked, but an incision was not made until the twelfth day; here also the lesion could not be found, and drainage was resorted to, but without avail, nephrectomy being subsequently required. Both children recovered.

Hydronephrosis is a condition characterized by distension of the pelvis and calyces with urine, as a result of some obstruction to its exit.

Causes.—(i.) It may be *congenital* in origin. It must be borne in mind that the body of the kidney is developed from the metanephros, and that the ureter unites subsequently with it to form its excretory duct; such union is occasionally defective at the upper end, well-marked obstruction occurring at the junction of the ureter with the infundibulum of the pelvis. Similar trouble sometimes arises from the ureter becoming kinked over an abnormally-placed renal artery. It is, however, more frequently due to an impervious condition of the urethra, or to the existence of a membranous septum therein; both kidneys are then necessarily affected. The amount of distension in some of these cases is such as to interfere seriously with parturition until the abdomen has been tapped. The infants are often born dead, or succumb shortly after birth. (ii.) *Acquired* forms of obstruction are by no means uncommon, and may be arranged under the following heading: (*a*) Blocks within the urinary passages from the presence of stones, parasites, foreign bodies, or even blood-clot; (*b*) changes of structure affecting the walls of the urinary passages—*e.g.*, inflammatory swelling of the mucosa, cicatrices, stenosis, or tumours; (*c*) kinking of the ureter in cases of floating kidney; and (*d*) the pressure of extrinsic tumours or cicatrices, as after pelvic cellulitis, or from uterine or rectal cancer. Hydronephrosis may be unilateral or bilateral; in the former case the obstruction arises within the ureter, or from some vesical condition involving its entrance into the bladder; in the latter case the cause is generally to be looked for below this spot.

It must be clearly understood that a sudden and absolute block never leads to hydronephrosis. Should it occur as the result of impaction of a calculus in one of the ureters or of ligature of the ureter, as has occurred in hysterectomy, the secretion on that side is totally suppressed as soon as the tension within the pelvis and calyces is sufficiently high. Atrophy of the renal epithelium follows after a time, but if the obstruction is relieved within six weeks of its incidence, the secretion of urine will probably be re-established. Should, however, the obstruction be intermittent or incomplete, so that some of the urine escapes, thereby relieving the pressure, hydronephrosis develops. Sudden and complete occlusion of the urethra likewise results in dilatation of the bladder and rupture either of that viscus or of the urethra, whilst a gradually increasing obstruction is always likely to lead to hydronephrosis.

Pathological History.—The earliest result of obstruction to the flow of urine consists in dilatation of the ureter and pelvis, which is soon followed by expansion of the calyces. The pyramids are flattened, and the cortex expanded and thinned, so that the whole kidney looks larger than usual (Fig. 539). A certain amount of interstitial infiltration of the cortex is always present; the urine secreted in the early stages is usually abundant and of low specific gravity.

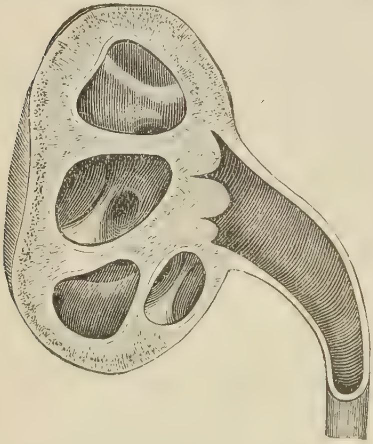
FIG. 539.—HYDRONEPHROSIS. (FROM SPECIMEN IN BRISTOL HOSPITAL MUSEUM.)

If the obstruction continues, the renal tissue becomes more and more atrophied, until finally it disappears entirely, the kidney being represented by a thin-walled multilocular cyst. At any stage septic phenomena may supervene, giving rise to pyonephrosis (*vide infra*).

The **Clinical History** varies considerably with the method of onset and the cause of the trouble. Frequently all that happens is a painless enlargement of the affected organ; if both kidneys are involved, there may be at first some increase in the amount of urine secreted, which is pale, limpid, and of a low specific gravity; after a time the quantity diminishes, and finally anuria and uræmia follow, especially if septic changes supervene, as is so commonly the case. When only one kidney is affected, the excretion may remain normal in quantity and quality, owing to compensatory hypertrophy of its fellow. An elastic swelling, fluctuant if of considerable size, is produced by hydronephrosis; it presents all the physical signs of a renal tumour (p. 1176), and its formation may be associated with pain, vomiting, and increased frequency of micturition. Finally, a perinephritic abscess may develop, owing to ulceration of the pelvis or ureter, and if this bursts externally, the cyst may eventually discharge through the loin. Occasionally the size of the tumour varies considerably from time to time, as a result of the obstruction being temporarily overcome by the pressure of retained urine behind it.

When due to a congenital stricture of the upper end of the ureter or to a kink over a branch of the renal artery, there is usually a history of occasional attacks of painful swelling on the affected side, which has disappeared when the patient rested. Urinary symptoms may accompany this, but it is often supposed to be a bilious attack, or a mild appendicitis. Some pyelitis may follow, but sooner or later an acute attack supervenes, which does not improve, and, if left, suppuration and perforation will follow. Such cases are by no means uncommon.

The **Treatment** of hydronephrosis should in the first place be directed to removal of the cause, if practicable, and where the obstruction exists in the prostate or urethra, no other treatment is feasible. In some cases of *congenital* hydronephrosis due to malformation of the upper end of the ureter, it is possible to transplant it and thereby relieve the obstruction; or the pinhole orifice of the ureter may be exposed within the pelvis, and divided longitudinally, with subsequent stitching open of the margins. This type of *uretero-plasty* is sometimes very successful. In the later stages, where suppuration is threatening or present, nephrectomy will probably be required. *Acquired* unilateral hydronephrosis may be dealt with by aspiration as a temporary measure; but this is rarely satisfactory, and usually needs to be followed by an exploratory incision (nephrotomy), by means of which it may be possible in a few cases to reach and deal with the obstruction. In the majority, however, the block is situated so low down that it cannot be reached, and the condition is often so aggravated that nephrectomy is the only reasonable treatment.

Nephritis, or inflammation of the kidney, is an affection which occurs in many different conditions, and is suitably discussed in medical text-books. The presence of albuminuria is of considerable significance to surgeons, and in all cases demanding surgical interference the urine should be carefully tested. It has been already discussed at p. 1179.

In addition, we must note that surgical interference has been utilized in cases of chronic Bright's disease. Edebohl* of New York and others have completely removed the capsule of both kidneys in some of these patients. The technique is simple, and needs no special description, but the operation is often difficult in fat œdematous subjects. It is claimed that this operation, or, perhaps better, nephrostomy (p. 1199), is most suitable to young people with post-scarlatinal chronic nephritis, and may save life when suppression of urine follows catheterism or exposure to cold. The further history of these procedures will be watched with much interest.

Pyogenic Infections of the Kidney and Ureter may develop from many distinct sources, and give rise to several allied, though distinguishable, clinical conditions. Thus, (i.) the infective material may reach the kidney from the blood in the shape of emboli, as in pyæmia, causing a diffuse inflammation of the renal substance with a development of many scattered abscesses (*acute suppurative interstitial*

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* *Medical Record*, March 28, 1903

nephritis), or of one larger abscess. Sometimes a focus of disease pre-exists in the kidney (*e.g.*, stone, tubercle, or cancer), and the superadded infection adds much to the gravity of the symptoms. (ii.) When once the kidney substance is involved, the trouble is only too likely to spread to the pelvis, causing a suppurative *pyelitis* (or, inasmuch as the renal parenchyma is already invaded, a suppurative pyelonephritis); and thence the mischief spreads down the ureter, and may perhaps infect the lower urinary passages, constituting a condition of *descending pyelonephritis*. (iii.) A common method of origin consists in pyogenic organisms spreading upwards from the bladder to the ureter and kidney. This may arise from a primary cystitis, but is seen most frequently in the affection which used to be termed 'surgical kidney,' and follows in the train of many diseases accompanied by cystitis—*e.g.*, stricture of the urethra, enlarged prostate, stone in the bladder, etc. It will be remembered that the ureter passes through the bladder in an oblique direction, and is guarded by strong sphincteric muscular fibres, and thereby the spread of infection upwards is rendered more difficult. It is probable, however, that the mucous membrane lining the orifice becomes itself inflamed, and a small plug of mucus develops within it, through which the germs are able to pass upwards. In other cases they certainly find their way *via* the lymphatics of the mucous membrane, which are continuous in the ureter and bladder. When the phenomena caused by this infection from below are limited to a suppurative condition, it is known as an *ascending pyelonephritis*; but if to them is added an element of distension, due to the cause being of an obstructive type, then the distended suppurating kidney is known as a *pyonephrosis*. (iv.) Sometimes the infection reaches the urinary passages from neighbouring organs, as in disease of the rectum or even of the appendix; in the former the bacteria are disseminated by the lymphatics; in appendicitis an abscess may open into the kidney or ureter, or the latter structure may be involved in the inflammatory deposit. In the female infection may easily spread along the short urethra from the vulva.

The organisms usually present are staphylococci, streptococci, or the *B. coli*, which, as will be seen later, is constantly associated with inflammation of the bladder.

1. **Pyelitis** is the term applied to an inflammation involving the pelvis of the kidney, the calyces, and perhaps the ureter. The chief causes from which it arises are: (*a*) The presence of a calculus, or the passage of uric acid crystals in gouty individuals; (*b*) tuberculous disease, either starting primarily in the kidney, or extending upwards from the bladder; (*c*) extension of septic inflammation from the bladder and urethra; (*d*) malignant disease of the kidney; (*e*) occasionally in floating or moveable kidney; (*f*) the ingestion of irritating drugs—*e.g.*, cantharides, turpentine, and even cubebs or copaiba; (*g*) the presence of foreign bodies, such as needles, bullets, and parasites—*e.g.*, the *Bilharzia hæmatobia* or the *Strongylus gigas*; (*h*) a pyæmic embolus; and (*i*) possibly cold. In the milder cases and in

the early stages it may be a simple catarrhal inflammation, but it is almost certain to become purulent if it lasts long.

Whatever the cause, the pathological phenomena are the same, consisting in the lining membrane becoming congested and thickened, and secreting a muco-purulent, or even purulent, discharge. Owing to the swelling of the mucous membrane, the entrance to the ureter is encroached on, and a certain amount of distension of the pelvis and calyces (hydronephrosis) follows. Where micro-organisms are present, as in cases due to distension from the bladder, the kidney is likely to be involved in the process (pyelonephritis), or the condition may be followed by a urinary abscess in the loin or suppurative perinephritis.

The **Symptoms** of pyelitis consist of pain and tenderness over the affected kidney, increased frequency of micturition, and the *intermittent* discharge of *pus in acid urine*. The intermissions are due to the inflammatory swelling of the mucous membrane, which temporarily blocks the upper entrance to the ureter, and necessitates a certain degree of pressure of the urine and pus accumulated in the pelvis of the kidney in order to overcome the obstruction. Necessarily, where pyelitis follows chronic cystitis, the acid reaction is neutralized if the urine in the bladder has become alkaline; in such cases a nocturnal elevation of temperature is usually noted.

The **Treatment** of pyelitis is mainly directed to the cause. Where this is removeable (*e.g.*, calculus or foreign bodies), an operation is advisable. In the ascending type, which originates in the bladder, treatment should be first directed towards the latter viscus. In the simple catarrhal variety the patient is kept warm, and his diet restricted to bland fluids; urotropine, alkalies, and sedatives are prescribed. If these measures fail and the condition becomes painful and purulent, the affected kidney should be explored, as a stone may possibly be present, and the pelvis drained temporarily (nephrostomy).

2. **Pyelonephritis,** or inflammation of the pelvis of the kidney together with the renal parenchyma, is almost invariably suppurative in type, and either due to extension upwards from the lower urinary organs, or to a local lesion of pelvis or kidney, such as calculous or tuberculous disease.

In almost all cases of pyelitis a certain degree of renal congestion is present; but when the condition becomes confirmed, and especially when infective matter is present in the calyces, it is certain to light up a subacute interstitial nephritis. In the latter stages bacteria invade the pyramids and travel upwards along the lymphatics or renal tubules, giving rise to abscesses, either scattered through the connective tissue of the organ or within its tubules, in either case seriously damaging its excretory function. In both instances it is possible for many of these minute foci of pus to run together and form a large collection, which in time becomes recognisable from outside; but more usually the patient dies of toxæmia or uræmia before that stage is reached. When the affection ascends from the bladder, it may commence suddenly and with acute symptoms, and then probably results from some surgical operation or simply from catheterism in a patient whose bladder is in a highly septic condition. The organisms find their way upwards along the lymphatics in the mucous lining of the ureters, and soon infect the pelvis; the walls of the ureters may in such cases be studded with miliary abscesses.

Clinical History.—In *acute* cases the symptoms probably commence with a severe rigor, associated with pain in the loins or back, headache, vomiting, great thirst, and probably some amount of drowsiness, perhaps passing into a condition of coma. The rigor may be repeated, or the fever may remain high without exacerbations, but if uræmia is present or threatening, the temperature may be subnormal. The kidneys are felt to be enlarged and tender, and the urine is usually diminished in amount, and, indeed, may be suppressed entirely; if any passes, it is high-coloured and contains albumen and perhaps blood, with some amount of pus, which is probably derived largely from the lower portion of the urinary track. The prognosis of the worst cases, which supervene on old bladder trouble, is nearly hopeless, the patient being almost certain to die of uræmia, especially as both kidneys are generally affected. In less acute cases, occurring perhaps in young people, secondary to a bacillary cystitis, the symptoms often improve in a few days and quiet down; but the urine is swarming with bacilli, and recurrence of the trouble is not uncommon. Abscess may sometimes supervene.

In the more *chronic* cases, the symptoms are those of pyrexia, at first only slight, but gradually increasing and taking on the hectic type. The kidney is slightly enlarged and tender; the urine contains epithelial cells from the pelvis or renal casts, and may be acid in the early stages, but is usually alkaline in the late. As the condition progresses, the temperature rises; the patient wastes; appetite and digestive functions flag; slight delirium supervenes at night; and unless the cause can be removed or dealt with effectively, death from uræmia is likely to follow. If, however, effective treatment of the cause is possible, recovery may follow, but the kidney is, of course, permanently damaged, and some degree of sclerosis is certain to ensue.

Treatment.—In the *chronic* variety, the cause must first be dealt with, but the surgeon must not forget that an acute attack may be easily lighted up by injudicious instrumentation or operations. Hence it is often desirable to drain and wash out the bladder first, as by a perineal cystotomy, rather than to dilate or divide a stricture of the urethra. An enlarged prostate or calculus must be removed, but it may be desirable to wash out or drain the bladder for a few days before undertaking such operations, so as to diminish the risks of infection. At the same time the patient is kept in bed, and encouraged to drink plenty of bland fluids. If the urine is swarming with the *B. coli*, an autogenous vaccine of that organism is desirable, and must be continued for some time in gradually increasing doses. In the *acute* form the patient is kept warm in bed, and plenty of fluid, such as milk or barley-water, is given; stimulants are avoided, as also opium. Hot-air baths, wet packs, and the hypodermic injection of pilocarpine, will suffice to get the skin to act well, and watery purgatives, such as jalap and scammony, are needed for the bowels. The loins are fomented or cupped, but if the urinary secretion is not re-established, or if it is suppressed, or if the phenomena of suppuration supervene, incision of the kidney and drainage of the pelvis (nephrostomy) are essential. It is sometimes remarkable to observe how rapidly the symptoms improve after such a procedure, and how quickly the urinary secretion is re-established.

3. **Pyonephrosis** is the term applied to indicate the association of a chronic pyelonephritis with distension of the pelvis and ureter, as a result of obstruction to the passage of urine. When unilateral, it is commonly due to the presence of a calculus, or of tuberculous disease, the obstruction being caused by the swelling of the ureteral mucous membrane; if the affection is secondary to obstruction in the lower urinary passages, it is usually bilateral. The lining membrane of the pelvis is inflamed, thickened, and perhaps ulcerated; decomposing urine and pus collect in the dilated pelvis and calyces, and a soft, friable, phosphatic calculus may develop, even in cases where the originating cause is not of a calculous nature. Obstruction to the outlet may lead to such an accumulation of pus as to constitute an abscess of the kidney, whilst a certain amount of perinephritis is always present.

The **Clinical Signs** are very similar to those of pyelonephritis, but to them are added those of an enlarged, tender, and painful kidney, and a more or less abundant pyuria, usually intermittent. The temperature is somewhat raised, especially at night, from the absorption of toxic products; the patient steadily loses ground, and becomes emaciated; the tongue is dry, the appetite diminished, and nausea and vomiting are sometimes present. The urine is generally scanty in amount, and if both kidneys are involved, the excretion gradually diminishes, leading to a fatal issue from uræmia, unless the patient dies previously from toxæmia or pyæmia.

Treatment.—Where both kidneys are involved as a result of some urethral or prostatic affection, no special treatment directed to the kidneys is feasible; but if the condition is unilateral, and not secondary to disease of the lower urinary organs, nephrotomy should be undertaken, and any removeable cause dealt with. Failing this, the cavity may be drained, or even nephrectomy performed.

4. **Abscess of the Kidney** may follow any of the conditions already alluded to, in which bacteria gain access to the organ from below, the pus then collecting in the pelvis and dilated calyces. It also occurs in connection with pyæmia, and sometimes develops after the general infective fevers. In acute interstitial nephritis the abscesses are multiple and at first small, being located between the tubules or sometimes within them; the pyramids then have a streaky-white appearance due to their infiltration with pus, and the abscesses form in the cortical substance at their base. Larger collections are caused by the amalgamation of several of the smaller. In pyæmia the

abscesses are preceded by infarcts, which appear immediately beneath the capsule as wedge-shaped areas of a chocolate colour, which turns a yellowish-white as suppuration occurs. The kidney becomes enlarged and tender, and can usually be felt from outside, but fluctuation is rarely to be detected. The abscess may burst into the pelvis and discharge through the ureter, but when due to an ascending pyelonephritis from obstruction this is not likely to be the case. The inflammation is more liable to spread outwards through the kidney substance, and give rise to a suppurative perinephritis. The general symptoms produced are similar to those present in acute pyelonephritis. Treatment of an abscess of the kidney consists in nephrostomy for drainage purposes, or perhaps nephrectomy.

The more chronic varieties are probably tuberculous in origin, and may then attain considerable dimensions, all that is noted being the lumbar swelling, whilst pyuria is not necessarily present, owing to the ureter becoming blocked.

5. **Perinephritis** cannot be recognised unless suppurative in nature; it results either from infected wounds or from ulceration involving the walls of the pelvis and calyces, or from the transmission of micro-organisms from the interior of a suppurating kidney or pelvis without any breach of surface. A perinephritic abscess may also arise from inflammation spreading from the intestine, appendix, pleural cavity, spine, ribs, or elsewhere.

The **Symptoms** may be acute or chronic in nature. In *acute perinephritis*, signs of deep suppuration in the loin are produced—viz., an indurated painful swelling, associated with fever, and perhaps preceded by rigors. The body is held stiff and rigid, with an inclination towards the affected side. Fluctuation may sometimes be detected when pus has formed, but the abscess is often so deeply placed that it is difficult to recognise at first; it is likely to point at the side of the erector spinæ, or may burrow forwards between the abdominal muscles, and find an exit on the anterior abdominal wall. Occasionally it bursts into the peritoneal or pleural cavities, or into the intestine. If it comes to the surface, it is preceded by congestion and œdema of the skin. *Chronic perinephritis* gives rise to no characteristic symptoms until an abscess forms which is large enough to be felt. Sometimes it is of a simple type, and does not suppurate; but the kidney becomes adherent to surrounding parts, and to such an extent as to render nephrectomy difficult and dangerous.

Treatment in the suppurating variety consists in giving exit to the pus through an incision at the outer border of the erector spinæ; the cavity is then carefully examined, and the cause of the suppuration, if possible, determined, and treated according to the requisites of the case.

Tuberculous Disease of the Kidney occurs in one of three forms. (*a*) It may arise in the course of **acute general tuberculosis,** when miliary tubercles are found studding the organs, but giving rise to no special symptoms. The patient is usually a child. Treatment, of course, is impracticable.

(*b*) It may **extend upwards** from a similar affection of the bladder, and then almost invariably involves both kidneys. The mucous membrane of the ureter becomes thickened and transformed into œdematous granulation tissue containing tubercles, and that of the pelvis and calyces is similarly affected; finally, the renal parenchyma itself becomes infiltrated with tuberculous tissue spreading from the pyramids. The patients are usually young adult males, and this fact is explained by their liability to genital tuberculosis. *Clinically*, enlargement of both kidneys is noticed, arising partly from the deposit of tubercle within the organ and partly from obstruction within the ureter. The symptoms caused by the renal mischief cannot at first be distinguished from those due to the vesical trouble. Perinephritic abscess occasionally follows, and the patient dies from exhaustion, toxic absorption, or uræmia. Treatment in these cases is of no avail.

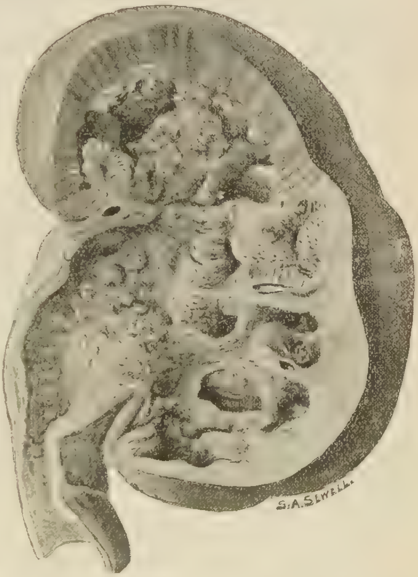


FIG. 540.—TUBERCULOUS KIDNEY, SHOWING THICKENING OF MUCOUS MEMBRANE OF PELVIS AND URETER. (FROM SPECIMEN IN COLLEGE OF SURGEONS' MUSEUM.)

(*c*) **Primary Tuberculosis** of the kidney is generally unilateral, and commences as a deposit of tubercle in the cortex or at the base of one of the pyramids. It may early involve the pelvis, and give rise to an ulcerative pyelitis, or may invade the renal parenchyma more particularly, replacing it by caseous masses, which in chronic cases may become calcified, and even cast a shadow on the radiographic screen. In the former case a tuberculous pyonephrosis follows, and the process spreads for some distance down the ureter, and even infects the bladder (Fig. 540). A *tuberculous ureter* is always thickened and hard, due to the infiltration of the mucous membrane; obstruction to the flow of urine and to the escape of discharge ensues, and in old-standing cases the ureter contracts and drags upon its outlet in the bladder, which can be seen to be retracted. Suppuration of a chronic type sometimes occurs in the kidney, and large quantities of pus may be dammed back behind the thickened ureter. Suppurative perinephritis may also supervene, and give rise to an abscess which bursts externally.

The **Symptoms** are at first indefinite. The patient is usually a young adult, and rather more frequently a male than a female. He complains of increased frequency of micturition, and unilateral pain in the loin, neither of which conditions is improved by rest, remaining the same at night as in the day, and, indeed, sometimes being worse. The pain is generally of an aching character, and more or less constant, although exacerbations may occur, taking on the type of mild renal colic, in consequence of the passage of fragments of disintegrated mucous membrane, or of caseous material. The urine is acid, and usually contains a certain proportion of pus, in which on examination the *B. tuberculosis* can sometimes be detected. More frequently they are not detected, unless the urine is centrifugalized, and cultivation or inoculation of the deposit may then demonstrate the presence of the bacilli. Hæmaturia is not marked, even if present at all. In the earliest stages albuminuria is sometimes present without any evidence of pus. On examination the kidney may be found to be slightly enlarged, but is not tender, except in the later stages, when it constitutes a tumour of considerable size, which may contain a large quantity of pus and even a phosphatic concretion. Loss of flesh, night sweats, and a nocturnal rise of temperature, are present in the later stages.

The **Diagnosis** of primary renal tuberculosis is usually a matter of doubt, if the presence of bacilli in the urine cannot be demonstrated, since the symptoms are very similar to those of *renal calculus*. The age of the patient and his personal and family history may be of importance, and he should be carefully examined for evidences of tuberculous disease elsewhere, especially in the genital organs. A bacteriological examination of the urine will often decide the case. The chief points of distinction clinically are that the symptoms are less influenced by exercise or rest, and there is less hæmaturia or renal colic than when a calculus is present, whilst the kidney is usually not so tender on manipulation; of course the condition is much less common than that of stone. Radiography will determine the presence or absence of a stone, but also of calcified caseous deposits. Cystoscopy may reveal the existence of tuberculous ulcers in the bladder close to the ureteral orifice in the earlier stages, or of a retracted ureter, when the latter has become transformed into a solid cord. In cases of doubt the final distinction is made by exploring the organ through an incision in the loin. In calculus the surface is uniformly even and dark red, and if any areas of softening are present, they are of a bluish-red colour; the pelvis and upper end of the ureter are usually lax and distended. The tuberculous kidney is generally mottled in colour and pallid-looking, whilst hard, scattered, caseous nodules may be felt, which become fluid on pressure, or on incision give exit to caseous pus. The condition of the ureter is also diagnostic; in calculus, if altered at all, it is thin and dilated; in tubercle it is thickened and indurated, and this condition may sometimes be detected on rectal or vaginal examination.

Treatment.—In the earliest stages the routine anti-tuberculous treatment (p. 184) may be employed, creosote (♏xv. or ♏ xx., t.d.s.)

being perhaps useful as a drug, and tuberculin in small doses being valuable. Operation must not be delayed too long, however, owing to the grave results that may follow from extension of the mischief. If on exploration of the kidney the disease is found to be strictly limited and the pelvis unaffected, it may be possible to cut or scrape away the diseased tissues, carefully purifying the cavity by liquefied carbolic acid, and packing the wound thus formed with gauze. In other cases it may be possible to excise wedge-shaped areas of the renal cortex, securing the wounds by sutures. In the majority of instances, however, the disease will have spread much too extensively through the ureter, pelvis, and calyces for such conservative treatment, or the kidney may consist of a series of cysts filled with offensive pus. If the surgeon is tolerably certain that the other kidney is healthy, nephrectomy should be performed, care being taken to divide the ureter below the farthest limit of the disease, the incision being suitably prolonged (p. 1209). The occurrence of a perinephritic abscess necessitates an incision in the loin, and through this opening the kidney can be explored and, if necessary, removed.

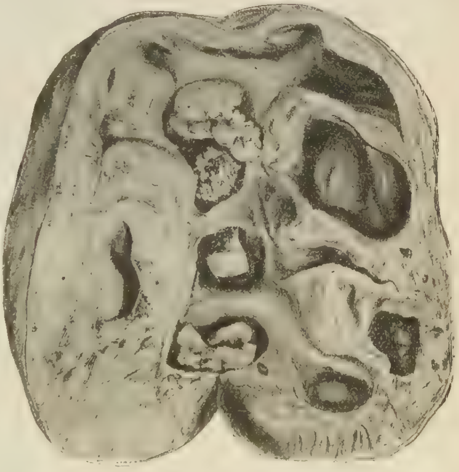


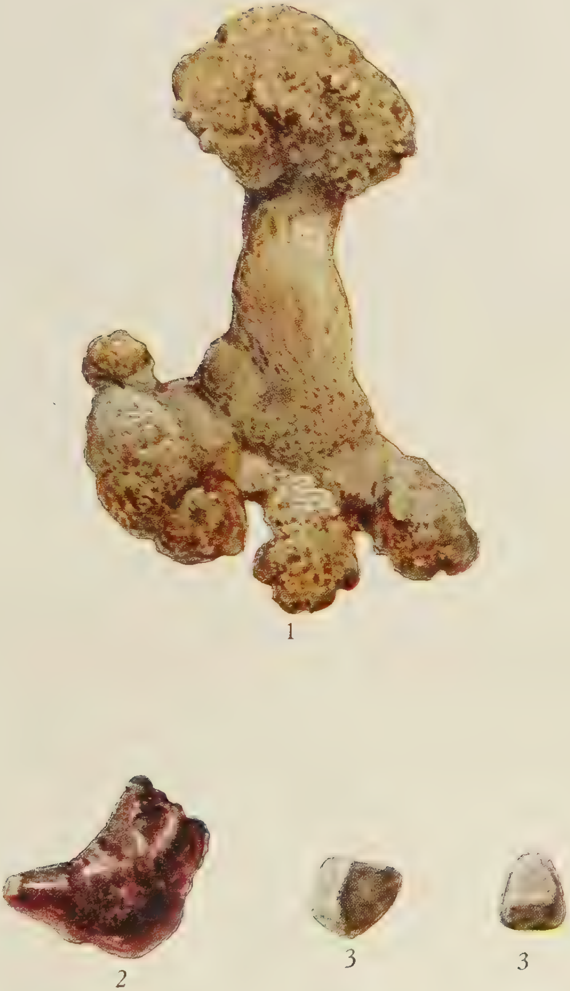
FIG. 541.—CALCULOUS KIDNEY. (COLLEGE OF SURGEONS' MUSEUM.)

Renal Calculus.—**Renal Calculi** are usually met with in individuals suffering from lithiasis, as indicated by the passage of sand or gravel in the urine. The general causes of this condition have been detailed elsewhere (p. 1184). All renal concretions are primarily excreted in a crystalline form from the renal tubules, but under ordinary circumstances are sufficiently small to find their way into the pelvis of the kidney, and thence along the ureter to the bladder. If, however, they are obstructed in their onward course, either on account of their size or shape, or some narrowing of the tubules, they may become lodged in the kidney substance or in one of the calyces, and by the gradual deposit of the same material increase in size until large enough to give rise to symptoms. Renal calculi are usually not of great bulk; occasionally, however, the whole of the pelvis, and some of the calyces, may be occupied by a concretion, which takes the shape of the cavity in which it lies (Plate XIII., Fig. 1). When many calculi are present in the pelvis of a kidney, they are usually faceted (Fig. 3). Chemically they consist either of uric acid or urate of ammonium; sometimes, however, they are composed of oxalate or acid phosphate of lime.

The **Pathological Phenomena** connected with renal calculi vary with their size, shape, number, and position. If situated in the substance of the renal parenchyma, they may give rise to but little trouble, being more or less encapsuled in a cavity lined by granulation tissue and surrounded by a dense fibrous capsule. Sometimes, however, ulceration of the wall and suppurative perinephritis may follow; the calculus may even find its way into the abscess cavity, and be discharged spontaneously or removed through the loin, a urinary fistula perhaps resulting. If the calculus is held in place in one of the calyces by its branched shape, thereby limiting its mobility, a suppurative pyelonephritis follows (Fig. 541), by which the kidney substance is seriously damaged, the pelvis may become dilated, and possibly perinephritis ensues, with or without suppuration, and the formation of a urinary fistula. When occupying the pelvis of the kidney, calculi set up a suppurative pyelitis, and from the obstruction to the flow of urine, caused partly by the thickening of the mucous membrane, and partly by the calculus engaging the orifice of the ureter, produce dilatation of the pelvis of the kidney, and the phenomena of hydro- or pyo-nephrosis. If the calculus passes down the ureter, it gives rise to the symptoms of renal colic. When small and smooth, it usually reaches the bladder without much difficulty, and is then voided with the urine, or remains as a vesical calculus.

FIG. 542.—RADIOGRAM OF MULTIPLE RENAL CALCULI. (DR. KNOX.)

PLATE XIII.



Renal Stones.

Fig. 1.—Large branched calculus, firmly held in the calyces of the pelvis. *Fig.* 2.—Oxalate of lime stone. *Fig.* 3.—Two facetted stones of uric acid. The patient passed two of this collection *per urethram* ; six were removed by nephro-lithotomy.

Occasionally, owing to its size or irregular shape, it becomes impacted in the ureter, usually at its upper end, giving rise to acute obstruction and the cessation of the urinary secretion on that side, followed in time by disorganization. If the kidney thus affected is the only one available for excretory purposes, or if both ureters are similarly obstructed, the patient, if unrelieved, dies in a few days from suppression of urine (*calculous anuria*). In other cases the stone ulcerates through the wall of the ureter, giving rise to a retro-peritoneal urinary abscess, or possibly to suppurative peritonitis. If the ureter is only partially obstructed by the calculus, the changes which take place in the kidney are more gradual, and result in hydro- or pyo-nephrosis.

The typical **Symptoms** arising from renal calculus are as follows: The patient complains of pain in the loin, more or less persistent, and often paroxysmal in nature, which is, however, always increased on exercise or jolting; it is frequently referred to distant regions, but most commonly follows the course of the genito-crural nerve, giving rise to pain in front of the thigh, accompanied by retraction of the testicle; in the female it is also experienced in the labium majus; sometimes it extends down the back of the thigh. It is almost invariably associated with hæmaturia, and often with pyuria, the amount of blood or pus being increased on exertion. Frequency of micturition is a prominent symptom, whilst if the pelvis is enlarged the kidney may be tender and distinctly palpable. If the calculus is lodged in the renal parenchyma, the urinary secretion may be but little influenced, although the characteristic pain is well marked; the patient also finds that at night he can only gain relief by lying on the affected side, and on manual examination the kidney, though somewhat tender, is not much enlarged. When the calculus lies in the pelvis or one of the calyces, the typical phenomena described above are produced; but it is then noticed that at night the patient lies on the sound side, since the organ is both enlarged and tender. On the other hand, it is an undoubted fact that stones even of large size may exist for years in the kidney without giving rise to any symptoms whatever.

The passage of a calculus down the ureter is accompanied by the symptoms known as **Renal Colic.** They consist of excruciating pain of a paroxysmal nature, which comes on suddenly, and is referred both to the loin and along the course of the genito-crural nerve. It is always associated with vomiting and severe shock, the patient often lying on the floor writhing in agony, with cold perspiration standing in beads on his forehead. The temperature is subnormal, and the pulse weak and rapid. Strangury is usually present, the patient suffering from frequent paroxysmal efforts to pass water, but only succeeding in passing a small amount, and that generally blood-stained. After lasting for a variable period, the pain suddenly ceases, as a result of the passage of the calculus into the bladder, or of its slipping back into the pelvis of the kidney.

Impaction in the Ureter may occur either 2 inches below the pelvis of the kidney, or near the brim of the pelvis, or near the vesical orifice, sometimes even protruding through it. There is usually only one stone, but occasionally more; the size is rarely greater than a coffee-bean, and the shape is usually somewhat elongated, like a date-stone.[*] In thin persons it has been detected on palpation through the abdominal wall, and when low down has been felt on rectal or vaginal examination. Persistent pain and hæmaturia extending over days or weeks should certainly suggest the presence of a ureteral calculus, and the more so if with each succeeding attack the pain and tenderness are located lower down. The result may be that the stone will ulcerate through into the retroperitoneal tissue, and be discharged in an abscess; or more frequently the kidney is disorganized, and perhaps the patient's life destroyed through the resulting renal incompetence.

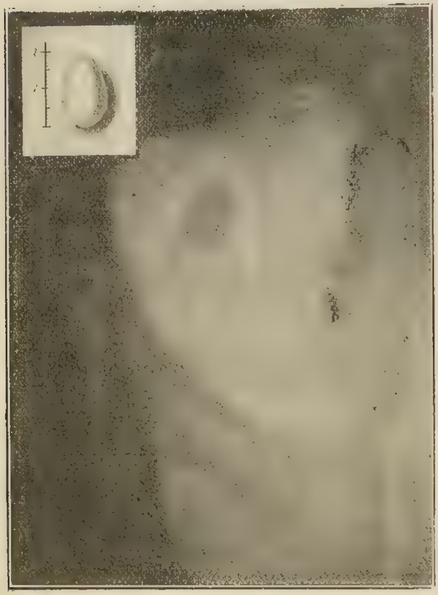


FIG. 543.—RADIOGRAM OF STONE IN THE PELVIC PORTION OF THE URETER.

The actual stone is seen in the inset against a centimetre scale; it was removed by a retro-peritoneal operation.

Occasionally the function of both kidneys is brought to an end—on the one side by the back pressure of urine due to the impaction of a small calculus; on the sound side, by reflex suppression of urine. In a case of this character recently operated on all the symptoms were on the left sound side, and in the unavoidable absence of a radiograph the kidney and ureter on this side were first explored and found normal; the peritoneum was then opened, and an impacted stone detected in the right ureter, and through a second incision this was removed. The urinary secretion was at once recommenced.

Should the ureter of a solitary kidney be blocked by a stone, grave symptoms of **calculous anuria,** or suppression, will arise. The condition is ushered in by pain in the loin of the usual character, which often passes away in two or three days. The anuria is rarely complete at first, a few ounces of pale limpid urine being passed at intervals, whilst occasionally distinct polyuria is present. Sooner or later definite uræmic phenomena supervene; the most usual period is seven or eight days after the onset, but incomplete obstruction or a pre-existing condition of hydronephrosis may delay matters. The onset of uræmia is indicated by persistent vomiting, a slow, full pulse becoming irregular, contraction of the pupils, and muscular tremors. Coma and convulsions are rarely seen, and there is no dyspnœa; the temperature is subnormal.

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[*] Sometimes a calculus will remain in the ureter for a considerable period, acting as a ball-valve, and permitting a certain amount of urine to pass. It may increase in size, and reach considerable dimensions. The author recorded a case (*Proceedings, Royal Society of Medicine*, vol. iii., No. 3, Clinical Section, p. 63) in which he had removed a stone from the lower end of the ureter weighing 803 grains. The ureter above it was dilated like a coil of intestine, and filled with pus.

The **Diagnosis** of renal calculus is often a matter of uncertainty in the absence of a history of the passage of gravel or of the occurrence of renal colic. It is most likely to be mistaken for tuberculous disease; the differential diagnosis between the two conditions has already been considered (p. 1202). The final determination of the presence or not of a renal or ureteral calculus is now usually made by radiography, which has made such advances that it may be relied on with almost absolute certainty, except perhaps in the case of small pure uric acid calculi.

Reference has already been made (p. 1187) to some of the conditions which must be observed if a reliable result is to be obtained. It is a good rule to follow that a second confirmatory examination should be made after an interval of two or three days in all cases where the diagnosis has not been established beyond all shadow of doubt. If a small stone has been located in the kidney, and operation has for some reason or other been deferred, it is always advisable that a confirmatory radiogram be taken immediately before the operation. Cases have been known where a stone had, during an interval, shifted its position from the kidney to within an inch or two of the lower end of the ureter without any symptom which could suggest the change of position.

Treatment.—In the early stages treatment is directed to the cure of lithiasis (p. 1185). The patient's diet and general habits of life must be suitably regulated, and he is instructed to make use of alkaline waters, such as those derived from Contrexéville or Vichy, or citrate of lithia and sulphate of soda may be administered in a mixture. Plenty of bland fluid should be ordered, such as boiled or distilled water, in the hope of softening the stone or assisting its onward passage to the bladder. Sometimes it may become encysted if the patient is kept absolutely at rest; the symptoms will then gradually improve, and finally disappear.

Attacks of renal colic are treated by the use of hot hip-baths, warm drinks, and hypodermic injections of morphia and atropine; in the more severe cases chloroform must be administered.

In former days, when the presence of a calculus could only be suspected from the history or symptoms, the question of operation and when to undertake it was a subject of much discussion. Even at that time Sir Henry Morris wrote that an 'unsuspected renal calculus is a source of very real danger; and when its presence is disclosed, whether by accident or by the systematic examination of the urine, we should recommend its immediate removal, regardless of the fact that it is not causing pain, unless the general condition of the patient contra-indicates an operation.' At the present day, when radiography has placed in our hands a means of almost certain diagnosis, the same advice holds good—*whenever a stone is found, remove it,* unless special contra-indications exist. Especially is this the case when a considerable amount of blood or pus is being passed in the urine, and the patient's temperature is raised. Pain in both kidneys is no contra-indication to operation, since there is no objection to exposing and even removing calculi from both organs. The constant passage of gravel, moreover, need not deter one from operating, for when once the kidney has been relieved by removal of the larger masses, the tendency to recurrence may be checked by suitable diet or drugs.

Nephro-lithotomy is always undertaken through the loin. When exposed, the kidney is carefully freed from its connections, and drawn up into the wound; in the majority of patients it can be brought out on the loin, and this is certainly a desirable manœuvre. The whole gland is then carefully palpated, as also the pelvis and upper part of the ureter, so as to locate, if possible, the stone. Should it be distinctly felt within the kidney substance, an incision is made over it through the renal parenchyma; free hæmorrhage follows, but this is readily controlled by inserting the finger into the wound, or by grasping the vessels in the hilum. Should the stone not be palpable, an incision is made through the convex border of the kidney substance, a little posterior to the mesial plane of the organ and at the junction of its inferior and middle thirds. One of the lower calyces is opened by this means, and the interior of the pelvis is carefully and fully explored by finger and probe. Sometimes the incision in the kidney has to be considerably enlarged, and the discovery of a small calculus may be a task of some difficulty. When the pelvis is much distended and the patient has previously passed a good deal of pus, careful precautions must be taken to protect the surrounding tissues from infection. Sterile gauze is packed into the angles and hollows of the wound, and the assistant must press up the abdominal wall. The incision is usually made through the cortex in preference to opening directly into the pelvis; but the objection often stated that a pelvic incision heals with difficulty, and is liable to leave a fistula, is not true, and most surgeons now deliberately open the pelvis in order to extract stones if it is more convenient to get at them in this way. Accurate suturing with catgut is generally successful in securing immediate healing, but the sutures must not encroach on the mucous membrane. Stones are removed by dressing-forceps, or scoop, and care must be exercised to prevent any from falling backwards into the ureter. Large branched calculi are often held very tightly, and require an extensive incision and careful peeling off of the kidney substance. The pelvic cavity need not be irrigated under ordinary circumstances, but when dilated and suppurating it is well to do so with a hot solution of sublimate or of Condy's fluid. Before closing the wound in the kidney the ureter should be thoroughly examined; it is sometimes possible to introduce a ureteral sound through the open wound, but this is by no means easy, and it is often wiser to make a tiny opening through the pelvic infundibulum, through which the sound is passed, and which is subsequently closed by a Lembert's suture. Bleeding is usually controlled without difficulty by stitches passed through the kidney substance, to which in bad cases may be superadded pressure by sponge or a gauze plug in the wound. It is useless to attempt to place a ligature on a vessel divided in the renal parenchyma. Should bleeding persist, sutures of the mattress type should be introduced and tied firmly. It is often wise to insert a drainage-tube down to the sutured wound in the kidney, after it has been replaced. The abdominal parietes may then be closed in the usual way.

To explore and expose the ureter the incision should be prolonged downwards and forwards in a direction parallel with Poupart's ligament towards the inguinal canal (the lumbo-ilio-inguinal incision of Sir Henry Morris). The peritoneum and its contents are pushed bodily inwards, and the ureter attached to the posterior peritoneal wall can be followed down to within a few inches of the bladder. For a stone impacted near the lower end of the ureter, **uretero-lithotomy** is performed with the patient in the Trendelenburg position. The operation may be trans- or retro-peritoneal.

1. The *trans-peritoneal* operation is conducted through an incision in the middle line. The stone is located, and, if possible, coaxed by the finger out of the depths of the pelvis to a more accessible position. It is then cut down on through the peritoneum, and the stone removed. The incision is closed by a Lembert suture or two.

2. The *retro-peritoneal* operation requires an incision similar to that for tying the common iliac artery. The peritoneum and its contents are displaced inwards, and the ureter is easily found running down on its posterior aspect. The stone is, if possible, displaced up from the pelvis, and removed. Cases seem to do equally well whether the ureter is sutured or not, granting that the stone is small. For large calculi, where much pus is present, it may be wise to drain the ureter for a day or two. The uncertainty of the local condition, which may be disclosed on operation, leads the author to favour the retroperitoneal operation as the safer of the two procedures. A calculus impacted close to the bladder has been removed through the rectum or vagina, or by a trans-sacral operation.

When the kidney is totally disorganized, **nephrectomy** may be required, but such treatment is not always advisable, especially when sinuses have resulted from a suppurative perinephritis. In such cases the renal tissue has often entirely disappeared, and disintegrating calculous material may occupy the pelvis, which is surrounded by a mass of dense fibro-cicatricial tissue, the removal of which is impracticable and even dangerous. All that should be attempted locally is the extraction of the stone and the purification of the cavity. If the inconvenience arising from the discharge of pus and perhaps urine in the loin is too great, it may be possible to check it in large measure by the plan suggested and practised by Colonel Holt, D.S.O.—viz., ligature of the renal artery.*

Tumours of the Kidney.—The different forms of tumour which originate in the kidney may be classified as the **simple** and the **malignant.** Several cystic conditions also occur. The general features of an enlarged kidney have been already described (p. 1176).

The **simple** tumours of the kidney are:

1. **Diffuse Cystic Disease** (or, as it has been termed, adenoma of the kidney), which may be congenital or acquired. It is not unfrequently bilateral, especially when congenital. The kidney is enlarged and occupied by cysts, varying in size, but rarely exceeding that of a cherry; they are lined with epithelium, which is generally flattened, and filled with a limpid fluid containing urea and perhaps cholesterine. The cysts are often very numerous, and may project from the surface of the kidney as nodular elastic outgrowths.

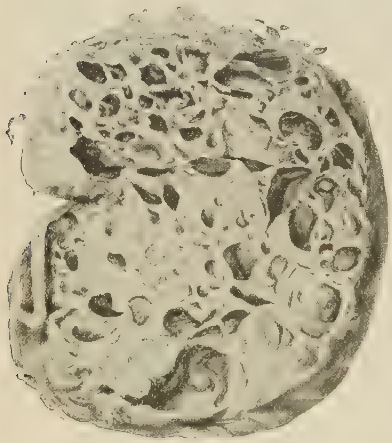

FIG. 544.—CYSTIC DISEASE OF KIDNEY. (KING'S COLLEGE HOSPITAL MUSEUM.)

The pelvis remains unaffected until the later stages of the disease (Fig. 544). Generally the whole kidney is involved, and may attain enormous dimensions, constituting large swellings which can be easily felt, and with a distinctly nodulated surface; occasionally the growth is limited to one portion of the organ. The origin of this condition is uncertain, but it is supposed to be due to the persistence of the mesonephros (or Wolffian body) in the substance of the true kidney (or metanephros), and its development into cysts. In the early stages no symptoms are produced, except, perhaps, a sense of dragging weight in the loins from the size of the tumours; but later on the secretion of urine is interfered with to such an extent as to produce renal incompetency and finally uræmia. The tendency of this affection to affect both kidneys prevents any hope of benefit from operation.

2. **Papilloma** of the renal pelvis is a rare condition, characterized by the development within its cavity of a villous mass, identical in structure with that met with in the bladder. It has usually been

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* *Trans. Royal Med. Chir. Soc.*, 1907.

observed in elderly people, and the chief, if not the only, symptom is excessive hæmaturia. It cannot be diagnosed with certainty, but if discovered in an exploratory operation, it can be removed with success.

Malignant tumours of the kidney may be divided into:

1. The **Sarcomata of Infants,** which are often congenital, but may be acquired within the first few years of life. They are encapsuled, the kidney substance being spread over them, and consist of round or spindle cells, the latter often showing a cross-striation, resembling that of muscular fibres (myo-sarcomata). They grow to a great size, and may affect both organs, but pain and hæmaturia are absent. Death results from general dissemination or from exhaustion, or may follow mechanical obstruction to the circulation, as by the detachment of a sarcomatous embolus, which travels upwards and blocks the pulmonary vessels. **Treatment** by nephrectomy has given most unsatisfactory results, the operative mortality having been high and recurrence almost invariable within a short period. The operation itself is not particularly difficult, but a large incision is required, and care must be taken to avoid displaced structures, such as the inferior vena cava. When both kidneys are affected nothing can be done.

2. The **Sarcomata of Adults occur** between the thirtieth and fiftieth years of life, and are of the spindle-celled variety, often originating from the capsule. Only one kidney is generally involved, giving rise to a rapidly-growing swelling, associated with hæmaturia and perhaps pain. Calculi are often found in the pelvis of such organs, and may be causative or consecutive. Secondary deposits form in the viscera; extension through and beyond the capsule is not uncommon, and death is usually due to exhaustion. The results of nephrectomy have not been very encouraging.

3. **Primary Carcinoma** is an uncommon form of tumour in the kidney. It presents the same clinical features as a sarcoma, except that there is rather more pain, and can only be recognised on microscopic examination. One symptom, however, requires special mention, since it is extremely suggestive of the presence of cancer—viz., the development of a varicocele. It is due to the pressure of enlarged and cancerous lymphatic glands upon the root of the spermatic vein, and hence, whenever an elderly person develops a varicocele, a careful examination of the kidney on the affected side should always be instituted.

4. The commonest tumours of the kidney, however, are the so-called **Hypernephromata** (75 to 80 per cent. of all renal tumours). They are looked on as growing from accessory and misplaced adrenals (*adrenal rests*), and develop primarily in the cortex as localized growths, gradually increasing in size and encroaching on the pelvis. They are of firm consistence, but show areas of necrosis and softening, and some deep red patches due to hæmorrhage (Fig. 545); the section is more or less mottled, and some bright yellow areas are very evident. On microscopic examination their appearance closely

resembles the zona fasciculata of the adrenal bodies, but this theory as to their origin is not universally accepted. They are malignant in type, being disseminated by the bloodvessels, and secondary growths are found in the lungs, liver, or bones.

Hypernephromata usually occur in adults between fifty and seventy years of age, and are of comparatively slow growth. They give rise to hæmaturia, but it is late in appearance, and less persistent than in other malignant growths of the kidney. Pain is often well marked and referred to the loin; it has two main types—a persistent aching pain, which may be very severe and wearing, and a colicky pain, due to the passage of clots down the ureter. The renal enlargement is usually characteristic, but outgrowths from diffusion beyond the capsule may render the swelling of irregular shape. **Treatment** consists in removal, if there is no evidence of secondary deposits in the lungs or elsewhere. The operation is by no means simple in cases that are at all advanced, as serious adhesions in various directions may be present, and the bleeding may be severe.

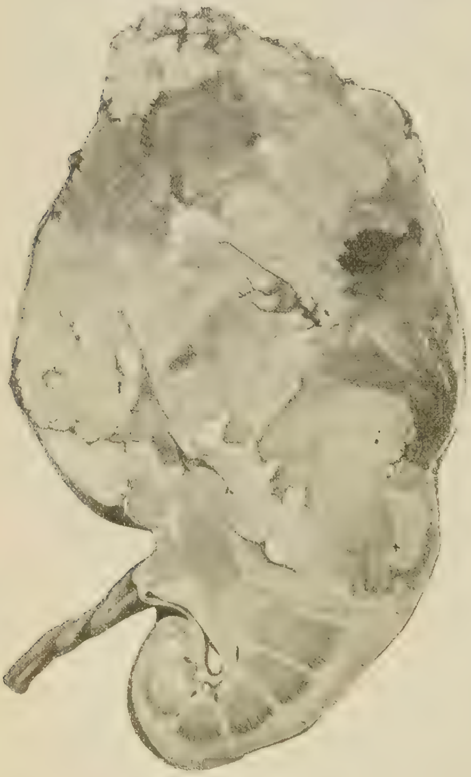


FIG. 545.—HYPERNEPHROMA. (KING'S COLLEGE HOSPITAL MUSEUM.)

Various **Cystic Conditions** of the kidney must be noted in addition to the general cystic disease, already described.

(*a*) **Hydatid Disease** affects the kidney, as it may involve any other organ in the body. It starts either beneath the capsule or in the glandular substance. In the former case it is likely to form a rounded projection, which may be detected on palpation of the loin; in the latter it expands, or even destroys, the whole of the glandular tissue, and may burst into the renal pelvis, the cysts being passed along the ureter, accompanied by more or less colic. Suppuration may complicate matters, but, unless the cyst has ruptured into the renal pelvis, diagnosis is scarcely feasible apart from an exploratory incision. *Treatment* consists in cutting down on the kidney, and enucleating the mass, if possible. Failing this, drainage may be undertaken, but in bad cases nephrectomy is necessary.

(*b*) **Dermoid Cysts** have also been found.

(*c*) **Serous Cysts** are occasionally met with, arising possibly as a result of obstruction to some of the ducts, or due to lymphatic obstruction. Rounded swellings, simple or multiple, are produced, growing outwards from the cortex, and containing a thin fluid, with a small amount of albumen and saline substances in solution. They give rise to no symptoms except from their size, and rarely require treatment other than simple aspiration or drainage. If discovered at an operation, and of considerable size, they should be incised, and either dissected out, or the outer wall cut away, and the inner left continuous with the renal capsule.

(*d*) Not unfrequently a number of small cysts develop in connection with chronic granular nephritis, but they are of no clinical importance.

Nephrectomy, or total removal of the kidney, is performed for the following conditions: (*a*) For tuberculous disease, when conservative measures have failed or are impracticable, or when the pelvis and ureter are extensively involved; (*b*) for calculous pyonephrosis, when the renal parenchyma is disintegrated; (*c*) for hydronephrosis, when palliative measures or drainage have failed to give relief; (*d*) for malignant disease; (*e*) for traumatic lesions, such as disintegration or rupture, especially if complicated by laceration of the peritoneum; and (*f*) for some cases of ruptured ureter.

Before undertaking the excision of any kidney, however diseased, it is essential that the surgeon should satisfy himself as to the existence of another, and also, if possible, ascertain that it is capable of undertaking the increased duties which will subsequently fall upon it. Many different plans of doing this have been already alluded to (p. 1176).

Nephrectomy may be undertaken through the abdomen or through the loin; but sundry combinations or modifications of these operations have been recommended by various authorities.

The *Abdominal Operation* is chiefly utilized when the organ is much enlarged, on account of the readier access obtained, especially to the pedicle. The peritoneum is likely to be opened, and may be exposed to septic contamination, when the pelvis and the upper part of the ureter are distended with decomposing pus, as is frequently the case; but this is easily prevented. Drainage is obtained for the cavity left after the removal of the organ by a counter-opening made through the loin. One great advantage, as before stated, is that the other kidney can be first examined, if required, and its condition ascertained. As to the technique: there is frequently no necessity to open the peritoneal cavity, since the kidney is almost always enlarged, but an opening is often made, intentionally or accidentally. The colon and peritoneum are peeled off the organ and displaced inwards; it is then freed from its adhesion to surrounding tissues, the surgeon endeavouring to keep outside its true capsule, but inside the layer of condensed perinephric tissue. Special precautions must be adopted in dealing with the deep aspect of the tumour, particularly on the right side, where it is occasionally adherent to the inferior vena cava. The mass is now lifted from its bed, and its pedicle, consisting of the ureter and renal vessels, isolated. These latter are secured separately by ligature and divided, a clamp being applied to the distal ends. The ureter is dealt with in the same way, small pieces of gauze being packed round so as to receive any secretion which may escape; the exposed mucous membrane in the portion which is left is carefully touched over with pure carbolic acid. The kidney thus freed is removed, and the wound in the abdominal parietes closed in the usual way, provision for drainage having been previously made either through the loin or from the front. Considerable shock is often experienced from this operation, and the death-rate is somewhat high.

Occasionally the perinephric adhesions are so firm and extensive that the only practicable plan of removing the organ is to enucleate it from within the capsule as far as the hilum; the capsule is then torn or cut through so as to expose the pelvis and renal vessels, which are secured.

The *Lumbar Method* can be employed when the kidney is not too greatly enlarged. The organ is exposed by the incision already described, enucleated from its surroundings, and the pedicle dealt with as in the abdominal operation. If the condition of the opposite organ has not previously been ascertained, the peritoneum should be incised at the outer margin of the wound, so as to enable the hand to be inserted across the middle line, and thus allow an exploration of the opposite loin.

Should it be desirable to include the ureter in the scope of the operation, the incision may be prolonged into the groin in the direction of the fibres of the external oblique, and the peritoneum and its contents pushed forwards; by this means it can be traced down almost to the bladder.

CHAPTER XL.

BLADDER AND PROSTATE.

Methods of Examining the Bladder.—When a patient presents himself complaining of increased frequency of micturition and other evidences suggestive of chronic disease of the bladder, a systematic examination of the individual and his urinary passages must always be instituted. The history of the case, the character of the symptoms, and the condition of the urine, are carefully gone into. An examination of the bladder should then be made. (1) The patient is laid on a couch, and the lower part of the abdomen uncovered. The hypogastrium is then examined by inspection, palpation, and percussion, so as to ascertain whether or not the bladder is distended, or if any abnormal resistance can be felt, either from thickening of the wall or the presence of a tumour. (2) A sound is then passed according to the method described at p. 1233, and the interior of the viscus explored; by this means a calculus may be detected, and even sometimes a tumour, as also a rough and irregular condition of the mucous membrane. (3) The finger is inserted into the rectum, or, in the female, into the vagina, before the sound is withdrawn, so as to enable the condition of the posterior vesical wall to be investigated between the point of the finger and the sound. Enlargement of the prostate or of the vesiculæ seminales can also be detected in this way. (4) The patient may then be asked to void urine, after which a rubber catheter may be introduced, and the amount, if any, of residual urine estimated. (5) As mentioned elsewhere, Bigelow's evacuator is useful, not only to wash out the bladder, but also to detect the presence of very small calculi which the sound may have missed. (6) Of recent years a new means of examining the interior of the bladder has been introduced in the shape of the *cystoscope*. This consists of a straight tube with a short end bent at an angle, in which an electric lamp is placed, the wires leading to it being carried within the tube. A small window covered with glass is situated close to the angle, and a prism is here inserted in such a manner that, when the surgeon looks through an eyepiece placed at the end of the instrument, he is able to see the portion of the vesical wall illuminated by the electric lamp. To use it the bladder must be previously washed out, if necessary, and the patient anæsthetized, if thought desirable. About ten or twelve ounces of boric acid lotion or clear water should be present in the bladder, so as to prevent the vesical wall from being injured by the instrument, which always becomes hot after the lamp has been used for some time. Considerable practice is needed for any useful information to be gained by the aid of this instrument, but in skilled hands much may be learnt as to the condition of the mucous membrane. (See Plate XIV.) Slight modifications of the instrument permit of the passage of a solid bougie or small catheter, which can be passed into the ureteral orifice and up the ureter (Plate XIV., Fig. 1). (7) Finally, in cases where great irritability of the bladder exists in spite of treatment, and its presence cannot be explained, an exploratory cystotomy, either suprapubic or perineal, is justifiable.

A *distended bladder* constitutes a rounded swelling, which projects above the symphysis pubis, and may even reach to the umbilicus in some cases

The swelling may be visible to the naked eye, and is dull on percussion, the dulness rising directly above the symphysis; it is quite immoveable, and therein differs from many ovarian and uterine tumours. Bimanual examination *per vaginam* or *per rectum* should at once indicate its nature; and when at all doubtful, a catheter should be introduced.

Congenital Affections of the Bladder.—1. **Ectopia Vesicæ, or Extroversion of the Bladder,** is the term employed to denote total absence of the anterior wall of the bladder and of the lower portion of the abdominal parietes, as a result of which the mucous membrane of the posterior vesical wall is exposed and rendered somewhat prominent by the pressure from behind of the abdominal contents (Fig. 546, 1). This surface is usually not much more than an inch in diameter in an infant, and is often irregular, and covered with papilliform processes; the orifices of the ureters are easily recognised below, urine being occasionally emitted from them in forcible jets. The condition is necessarily one of the greatest discomfort, not only from the constant dribbling of urine causing excoriation and eczema of the thighs and surrounding parts, but also from the pain and irritation due to friction of the clothes against the exposed mucous membrane. The symphysis pubis is always absent, and the horizontal ramus of the pubic arch terminates on either side in the inguinal region (4). The innominate bones are usually rotated outwards, and the sacrum is convex anteriorly from side to side instead of being concave. In consequence of this pelvic malformation, the patient's gait and powers of progression are considerably impaired. The penis (2) is cleft, and in a condition of complete epispadias; it is drawn upwards and backwards over the trigone, so that it requires pulling down to expose the ureteral orifices. The testes are often found in the inguinal canal, or, if in the scrotum, are accompanied by congenital herniæ. No umbilicus is present. The condition is due to impaired development of the anterior wall of the allantois and the lower segment of the abdominal parietes. At birth the lower

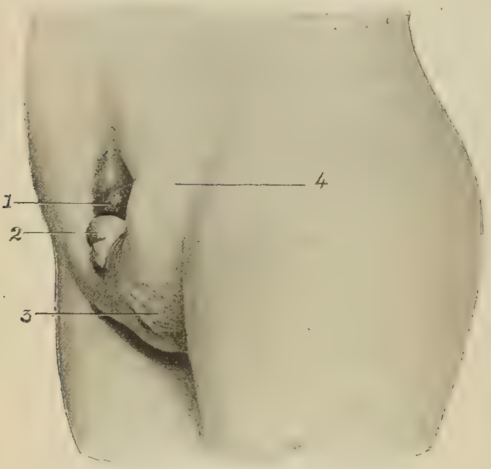
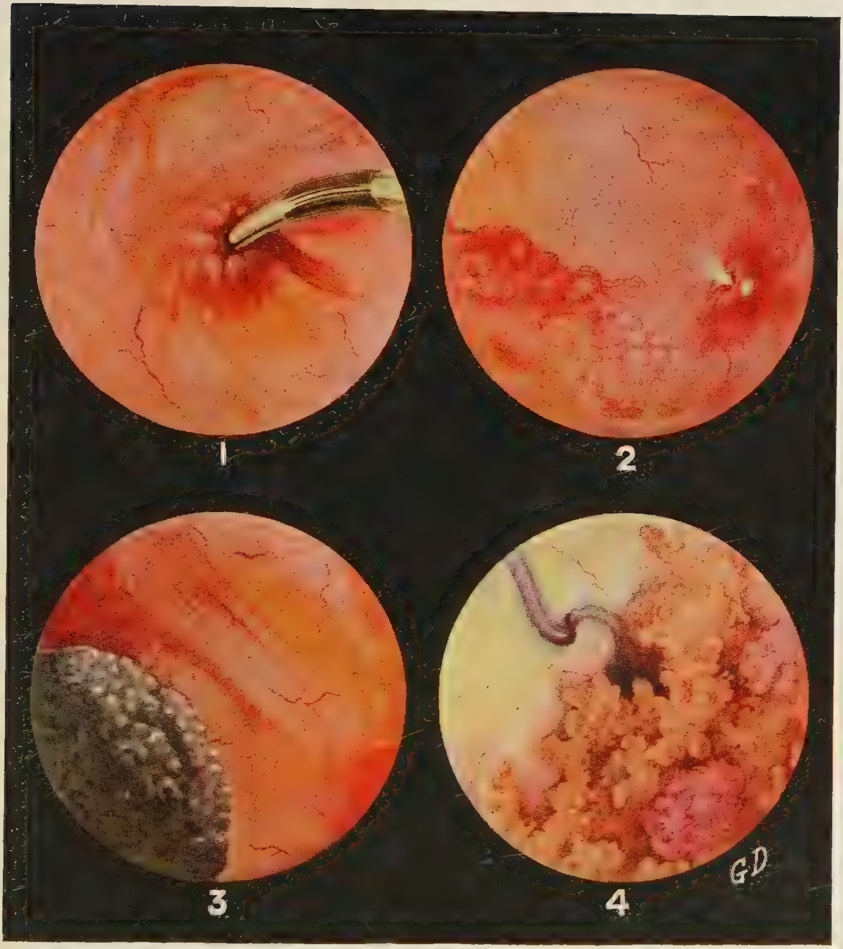


FIG. 546.—ECTOPIA VESICÆ.

1, Exposed mucous membrane of posterior wall of bladder; 2, glans penis drawn up to cover lower part of vesical mucosa and orifices of the ureters; 3, scrotum; 4, projection of pubic ramus.

PLATE XIV.



Cystoscopic appearance of the Bladder in various conditions.

Fig. 1.—Passage of ureteral catheter through a somewhat congested right ureteral orifice.

Fig. 2.—Tuberculous bladder and kidney. The left ureteral orifice is thickened and pouting ; a small tubercle is seen on the outer side of it ; a spurt of pus is being ejected from it. Towards the middle line is seen a more diffuse tuberculous infiltration of the vesical muscosa.

Fig. 3.—Stone in Bladder.

Fig. 4.—Papilloma of Bladder.

[*To face page 1216.*

portion of the umbilical cord is expanded over the raw surface, constituting the anterior vesical wall. When the cord separates, the posterior vesical wall is necessarily exposed.

The **Treatment** of this distressing malformation is most unsatisfactory, and hence in the majority of the cases the application of a urinal has been recommended, although the instruments hitherto devised are not particularly efficient. Various *operative measures* have also been practised. (*a*) Trendelenburg's operation consists in division of the sacro-iliac ligaments from behind so as to enable the lateral halves of the pelvis to be compressed together. By this means the posterior vesical wall is thrown backwards and its tendency to protrude lessened. The wounds are allowed to granulate, and, if successful, the bladder wall finally lies at the bottom of the sulcus, which can usually be covered over by a plastic operation without much difficulty. The main objections to this method are that it involves a very severe operation, and also leads to a further weakening of the pelvic arch, the integrity of which is already much impaired by the absence of the pubic symphysis. (*b*) Plastic operations without interfering with the pelvis were introduced and practised by the late Professor John Wood, Thiersch, and others. For full details, we must refer to larger text-books. Suffice it here to state that a skin flap is turned down from the anterior abdominal wall above the breach of surface, and sutured on either side to the margins of the defect. The cutaneous surface of this flap constitutes the anterior wall of the newly-formed bladder, if such it can be called, whilst its raw outer surface is covered in either by flaps derived from either side, or by undercutting the neighbouring skin and sliding it inwards to the middle line, where it is united by sutures, as suggested and successfully carried out by Mr. Boyce Barrow. The after-treatment is always prolonged and tedious, and the patients are likely to experience much subsequent inconvenience owing to the growth from the under surface of the abdominal flap of hairs, which become encrusted with phosphates. (*c*) More recently various methods of implanting the ureters into the rectum have been practised, and it is claimed that the urine is easily retained for some hours, and voided independently of the fæces. This is much the best procedure, although the patient runs the risk of an ascending infection of his urinary track.

2. An **Umbilical Urinary Fistula** is sometimes met with as a result of imperfect closure of the urachus.

3. Occasionally in cases of malformation of the rectum the **Primitive Cloacal Condition** may in part persist (see p. 1145).

Traumatic Affections of the Bladder.—**Rupture** may be produced in several ways: (1) It may be due to direct violence applied to the lower part of the abdomen, especially when the viscus is distended. (2) It may complicate a fracture of the pelvis, either as a direct result of the violence, or from penetration of a spicule of bone from the os pubis. (3) The bladder may be opened by a penetrating wound. (4) Apart from traumatic lesions, rupture may occur from simple over-distension, especially if destructive ulceration of its walls is present; or it may follow ulceration of a saccule if it contains a phosphatic concretion.

Rupture of the bladder is divided into two main classes, according to whether or not the peritoneal cavity is opened. The peritoneum covers the upper and back part of the viscus, being reflected anteriorly along the urachus, laterally along the obliterated hypogastric arteries, and posteriorly on to the rectum.

Intraperitoneal Rupture involves the posterior or superior portions of the viscus, and is the variety most frequently met with. The symptoms produced are severe shock, associated with hypogastric pain of a burning nature. The patient experiences a constant desire to micturate, but, as a rule, nothing is passed, except perhaps a little blood. Peritonitis soon follows, running a rapidly fatal course, especially if efficient treatment is not adopted. On passing a catheter the bladder is usually found empty, or possibly a little blood-stained urine may be withdrawn; if, however, the instrument happens to be insinuated through the rupture into the peritoneal cavity, a considerable quantity of blood-stained urine can be drawn off, and the point of the catheter may be felt under the anterior abdominal wall. A useful diagnostic sign consists in injecting a measured amount of boric acid lotion into the bladder, and noting how much of it returns; when a rupture exists, some considerable discrepancy will probably be noted between the two quantities; this test cannot, however, always be relied on.

The **Treatment** of these cases consists in immediate laparotomy; the fluid within the peritoneal sac is removed by swabs, and the wound in the bladder clearly demonstrated, preferably with the patient in the Trendelenburg position (p. 960), which must not, however, be adopted until the urine and inflammatory effusion have been removed. The rent is carefully closed by means of a row of Lembert sutures, not involving the mucous membrane, which should always extend a little beyond each extremity of the wound. Possibly a drainage-wick or a Keith's tube may need to be inserted for a few hours, so as to remove any exudation. The abdominal wall is then closed in the usual way, and the patient put back to bed. The urine is either drawn off at regular intervals, or a catheter may be tied in the bladder, the urine being syphoned by an attached rubber tube into a vessel placed beneath the bed.

Extraperitoneal Rupture of the bladder involves its anterior wall or base. The urine finds its way into the pelvic cellular tissue, and if unhealthy at once gives rise to a most virulent form of suppurative pelvic cellulitis, which is usually fatal from toxæmia or pyæmia. Abscesses generally point either above the pelvic brim or in the perineum. The treatment consists in free incisions through the perineum, or above the brim of the pelvis. In the latter case it may be possible to reach the rent in the bladder and suture it; otherwise it may be possible to introduce into the bladder a large tube, through which the urine can escape freely for a time. As soon as the tissues are sealed off by the development of granulations, the tube may be withdrawn. The prognosis largely depends on the condition of the urine, whether healthy or contaminated with bacteria, and on the length of time it was allowed to remain in contact with the tissues.

Foreign Bodies introduced into the bladder from without are of various natures, such as portions of catheters or bougies, pins, etc. They give rise to symptoms of chronic cystitis, and usually become encased with phosphatic deposit. They should be removed as early as possible with a lithotrite, but if of large size or thickly covered with phosphates, must be treated by perineal or suprapubic cystotomy. In the female, digital dilatation of the urethra is the best means of gaining access to the interior of the viscus.

Cystitis may be due to a great variety of causes, but is always in essence of bacterial origin. Many different forms of bacteria may be found, but those most usually present are the ordinary pyogenic cocci, especially the *Staphylococcus aureus*, which, together with the *Diplococcus ureæ liquefaciens*, has the power of decomposing urea and setting free ammonia, whilst the *B. coli* is also commonly found in these cases. This latter organism has no power of rendering the urine alkaline, and, indeed, develops badly in alkaline media, and hence if present in a pure infection the urine remains acid, though stale and offensive to the smell. The *methods of invasion* of the bladder are diverse: (1) Bacteria may reach the viscus from above, either owing to a suppurative lesion of the kidney or its pelvis, or escaping into the urine from the blood. (2) They may travel up the urethra. This is a matter of no difficulty in the short and comparatively large urethra of a woman, and hence cystitis is frequently associated with vulvitis or is seen after labour. In girls a pure bacillary cystitis with acid urine is not uncommon, and is probably secondary to a vulvo-vaginitis, which arises from contamination of the vulva with the fæces where cleanliness is neglected. In the male sex, infection from the urethra is unusual unless urethritis has previously existed or some irritation, due to the passage of instruments. Even if they are carefully sterilized, mucus is liable to form and cling about the urethral wall, and along this bacteria can find their way. Naturally the introduction of an unsterilized dirty instrument may suffice to cause cystitis. (3) Bacteria can invade the bladder from surrounding organs, being transmitted by lymphatic dissemination. Thus an injury of the rectum may easily lead to cystitis.

The mere presence of bacteria in the bladder is, however, not sufficient as a rule to determine an attack of cystitis. Large quantities of pus are frequently discharged from the kidney through the bladder, and that over lengthy periods, and yet no inflammatory reaction follows. Some *local predisposing factor* must be added in order to excite their activity, and amongst the most favourable are the following: (i.) Congestion of the mucous membrane, determined by exposure to cold; this is peculiarly liable to occur in gouty individuals, and, indeed, there are people who ‘ take cold ’ in their bladders instead of developing a nasal or bronchial catarrh. (ii.) Injury, as by the presence of a foreign body, a calculus, or rough handling during an operation, may serve to render bacteria active and virulent. (iii.) One of the most important causes is retention of urine, from whatever cause it is due—*e.g.*, enlarged prostate, stricture, etc. The bacteria develop and decompose the urine, rendering it offensive and ammoniacal, and the toxins and irritating bodies thereby produced affect the vesical mucosa. (iv.) The presence of irritants in the urine may determine cystitis, as also pyelitis—*e.g.*, after the absorption of cantharides. Other drugs may light up bacterial activity in some predisposed individuals—*e.g.*, copaiba or cubebs. (v.) Loss of nervous control is a most important predisposing factor, and comes prominently into play in spinal injuries. The greatest difficulty is experienced in protecting such patients, and even effective purification of penis, hands, and catheter and the application of a sterilized dressing to the organ after the catheter has been used, may not suffice to prevent an outbreak of cystitis, which is due to infection from the kidney or rectum. In these patients the disease always runs a virulent course, and is likely to kill the patient by extension up the ureter.

Pathological Anatomy.—In acute cases the mucous membrane of the bladder becomes congested and thickened; the epithelium is shed; mucus is excreted, and is soon transformed into muco-pus, which may be extremely viscid, and develops in large quantities. Ulceration of the bladder wall may occur, or even sloughing; in the worst cases the whole of the mucous lining may necrose, and be cast off as a slough. Sometimes a membranous form of inflammation occurs, the patient frequently passing flakes of some size, which on examination are found to be chiefly composed of fibrin.

In chronic cases the mucous membrane is thickened and congested, the superficial veins dilated and even varicose, whilst ulceration is not uncommon. The continued repetition of the act of micturition leads to hypertrophy of the bladder wall, which becomes thickened and fasciculated; this effect is of course most marked when the cystitis is associated with obstruction to the outflow of urine. The mucous membrane may protrude outwards between the muscular fasciculi, giving rise to pouch-like saccules, in which phosphatic concretions are sometimes formed, and the retained urine undergoes decomposition. Perforative ulceration occasionally follows, originating a fatal peritonitis or pelvic cellulitis from extravasation of urine. The contracted state of the bladder and the overgrowth of its muscular substance lead to compression of the openings of the ureters, hydronephrosis being thus induced. A plug of viscid mucus often finds its way into the ureteral orifice, and by becoming infected with bacteria causes an extension of the infective mischief to the kidney.

The **Symptoms of Acute Cystitis** consist in pain referred to the perineum and hypogastrium, together with tenderness on pressure over the symphysis pubis. This is accompanied by extreme irritability of the bladder, frequent efforts of a painful and spasmodic nature being made to pass water (strangury); but little urine is voided at a time, for as soon as any amount has collected it is ejected forcibly. It generally contains blood and pus, soon becoming alkaline, and teeming with bacteria. Some amount of fever is generally noted, as also vomiting, whilst tenesmus may be induced as a result of the proximity of the rectum to the inflamed bladder. The usual termination of the case is in resolution, but sometimes chronic irritability may persist. In rare instances the inflammation is of such a virulent nature as to cause death. The urine in these cases is often exceedingly foul, and the fatal issue is due to exhaustion, peritonitis, suppurative pyonephrosis, or even acute toxæmia. In some patients, however, when the inflammation is concentrated at the neck of the bladder, retention, distension, and atony may ensue.

Treatment.—The patient should be kept in a warm atmosphere, and preferably in bed, and fomentations applied to the lower part of the abdomen; hot hip-baths twice daily, maintained for some time, are very advantageous. The diet should be restricted to fluid, and the patient encouraged to partake freely of barley-water and other bland liquids. Alkalies and henbane may be administered, and morphia and belladonna suppositories are useful to allay the pain and irritability. As a rule, no instrument should be passed during the acute stage, unless retention is present; but if the urine becomes very foul, the bladder may be gently washed out, or even drainage of the bladder through the perineum may be necessary (see Perineal Cystotomy, p. 1223). Urinary antiseptics, such as urotropine (5 to 10 grains three or four times a day), salol (10 to 20 grains,) and boric acid (15 to 20 grains), together with acid phosphate of soda, administered by the mouth, may do good.

Chronic Cystitis is much more common than the acute variety, and is usually associated with some irritation of the walls of the viscus, as from calculi, tumours, foreign bodies, tuberculous ulceration, or retention and decomposition of urine, especially if associated with obstruction to the outflow, as by a stricture or enlarged prostate. It may also follow acute cystitis.

The **Symptoms** are those of irritability of the bladder, the patient constantly desiring to pass water, and having to rise at night, perhaps several times, for this purpose. The urine becomes turbid, and, on standing, deposits a variable amount of mucus or muco-pus, mixed with epithelial cells, crystals of triple phosphate, and a granular sediment of phosphate of lime. It is usually alkaline (unless due to a pure infection with the *B. coli*), perhaps foul-smelling and ammoniacal, containing an abundance of micro-organisms. There is often but little pain, though when a calculus exists, or the neck of the bladder is ulcerated, this may become a prominent symptom. The patient's general health is not at first affected; but if the symptoms persist it soon becomes impaired—partly from the absorption of septic products from the bladder, and partly from the want of rest and sleep arising from nocturnal disturbance—and this may be so marked as to lead to fatal exhaustion. In other cases the inflammation may spread from the bladder along the ureters to the kidneys, and the phenomena of septic pyelonephritis manifest themselves (p. 1197).

The **Diagnosis** of chronic cystitis is readily made from the characteristic symptoms of irritation of the bladder and the condition of the urine; but considerable difficulty may be experienced in determining its cause. In investigating a case, not only must the character of its onset be considered, but also the general history of the patient; whilst a thorough examination of the lower urinary passages must be instituted, and the urine examined microscopically and bacteriologically. The passage of a catheter or sound will generally detect any obstruction located in the urethra, whilst the bladder is also examined by the cystoscope and other methods described at p. 1215.

The **Treatment** of chronic cystitis is naturally directed towards its cause, if such can be discovered; thus, calculi or foreign bodies should be removed, and a stricture dilated. In most cases, even where the cause is not apparent, great benefit will be derived from washing out the bladder.

The bladder is best irrigated by passing a soft rubber instrument to the end of which is attached a portion of drainage-tube, about 3 feet long, and beyond this a glass funnel, into which the material employed is poured. By raising the funnel the fluid runs into the bladder, whilst on depressing it below the bed or couch the fluid returns on the syphon principle. The patient's sensations must guide the surgeon as to how much fluid can be borne in any particular case. Various solutions are employed for this purpose, but perhaps the most useful are weak Condy's fluid, sanitas (1 in 10), boric acid (20 grains to 1 ounce), perchloride of mercury (1 in 5,000), a neutral solution of quinine (2 grains to 1 ounce), or nitrate of silver (¼ grain to 1 ounce), and they may be used alternately with advantage. The frequency with which the injections are made must vary with the severity of the symptoms; it is not often necessary to perform the operation more than once or twice a day. Of course the most stringent precautions must be taken as to sterilization of the patient's penis, of the surgeon's hands, and of the instruments employed.

At the same time that this local treatment is being adopted, the patient's general habits of life must be regulated. The diet should be bland and unstimulating; alcohol is better avoided, but if essential for other reasons, well-diluted gin or whisky may be given. Tea and coffee should be prohibited, whilst milk should be given freely, together with barley-water and some mild alkaline water—such as that derived from Contrexéville. As to medicines, there are none which can alter the reaction of the urine from alkaline to acid, but perhaps salol, boric acid, or benzoic acid may be of some assistance. Urotropine is useful, acting by setting free formalin in the bladder. Hot infusions of buchu, uva ursi, and triticum repens act as mild diuretics, and as alteratives to the vesical mucous membrane; full doses, however, such as a pint or a pint and a half in the course of the day, are needed. Where much muco-pus is excreted, copaiba, cubebs, turpentine, or sandal-wood oil may be given, whilst injections of dilute astringents have been advised, but must be used with caution.

Vaccine treatment should be employed if the *B. coli* is the active organism; but in such cases the results are often very disappointing, possibly because the vaccine is in the blood and the bacteria in the urine. The patient may remain apparently well, and yet the urine teems with bacteria, and occasional bouts of cystitis occur, which must be treated by alkaline drugs and by washing out the bladder either with Condy's fluid or with a very dilute solution of nitrate of silver.

In cases which do not improve, and if the patient is becoming exhausted from the constant interference with his rest, etc., the only means of treatment left is that of opening the bladder through a perineal incision. **Perineal Cystotomy** is undertaken not only for draining a chronically inflamed bladder, but also to explore the mucous lining of the viscus to remove growths and foreign bodies, as also sometimes to deal with prostatic enlargements and calculi. The bladder is first thoroughly washed out, a few ounces of antiseptic solution being left within it. After anæsthesia has been induced, a staff with a median groove is passed into the bladder, and then the patient is placed in the lithotomy position, and the perineum shaved. An incision is made in the middle line of the perineum, from a point $2\frac{1}{2}$ inches in front of the anus to about 1 inch from that opening. The knife divides the deeper structures of the perineum, and, guided by the left index finger in the wound (Fig. 547), is made to enter the groove in the staff at a point corresponding to the membranous portion of the urethra. It is then carried upwards and backwards along the groove, incising the prostate and entering the bladder.

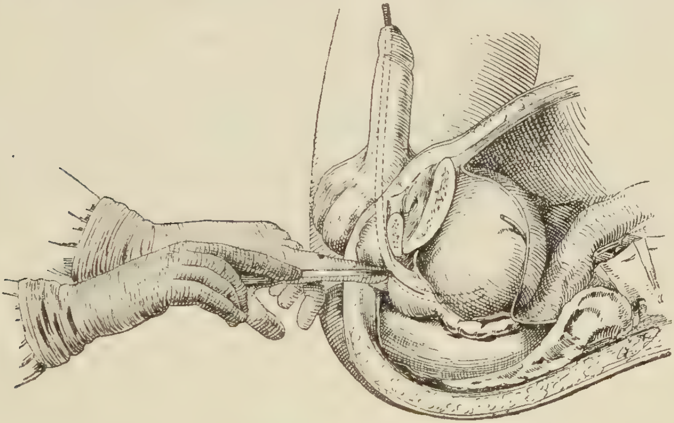


FIG. 547.—PERINEAL CYSTOTOMY (FERGUSSON.)

The knife is carefully withdrawn, the finger gently inserted into the cavity, and the staff removed. After digital exploration of the bladder, a full-sized gum-elastic catheter (No. 16 or 18) is passed in through the wound and fixed, a long piece of rubber tubing being attached to allow of the constant escape of the urine, as well as to permit of occasional irrigation. The catheter is removed and changed at the end of forty-eight hours, and in favourable cases may be discontinued altogether at the end of a week; in severer cases a permanent opening may have to be maintained.

Complications and Dangers of Perineal Cystotomy.—(1) *Hæmorrhage* may arise from the superficial arteries of the perineum, the deep branches of the pudic (especially that which passes to the bulb), and the veins of the prostatic plexus. The first of these are divided in the superficial incision, and may be readily secured by forceps. If the artery to the bulb or its branches in the bulb are cut, free hæmorrhage follows, which is usually stopped without difficulty by opening up the wound and seizing the bleeding points with forceps, or by packing around a catheter. Venous hæmorrhage from the prostate is more serious, and is especially prone to occur in elderly persons. Venous blood wells up from the depths of the wound, or passes back into the bladder, which becomes distended with clot, considerable pain being thereby induced. It is treated by syringing out the wound with iced lotion, and the insertion of an air tampon or a petticoated tube. The former contrivance consists of a gum-elastic catheter, the deep portion of which is surrounded by an indiarubber bag, which can be inflated with air through a small tube fitted with a stop-cock, to which a force-pump can be attached. The petticoated tube is used when the former is not obtainable or fails to act; it is made by tying a petticoat of lint or gauze around the distal end of a vaginal tube; this is then passed into the bladder, and the space between the petticoat and the tube packed with gauze If the bladder becomes filled with blood-clot, this must be broken up and removed by syringing with hot water through a large-eyed catheter, and the wound subsequently plugged around a catheter. (2) *A Wound of the Rectum* may be caused by carrying the incision too far backwards, or by not maintaining the point of the knife strictly in the groove; it is more liable to happen, however, whilst withdrawing the knife, the point being swept backwards, thus opening the bowel. It is often not recognised until flatus and fæces are passed through the wound at a later date. If of small size and situated low down it will probably close by cicatrization without special treatment; but when high up and more extensive, a recto-vesical fistula is likely to follow. The treatment usually recommended in such a case is to divide the sphincter, and thus lay the lower end of the rectum and the cystotomy wound into one cavity, the communication being sometimes closed by the contraction of the granulation tissue which fills up the wound. In suitable cases it may be possible to stitch up the opening from the rectum after paring its edges. (3) *Pelvic Cellulitis* is caused by cutting beyond the limits of the prostate, and thus opening up the recto-vesical fascia, or by bruising and over-distension of the neck of the bladder by dragging through it too large a stone. In either case urinary extravasation and diffuse septic inflammation are likely to follow, resulting in grave constitutional disturbance of a septic nature, and possibly in the death of the patient. The treatment suggested is to support the general health by suitable diet and stimulants, whilst local tension is relieved by extending the wound backwards even into the rectum. (4) An acute ascending pyelonephritis is occasionally lighted up, in spite of all precautions, and cannot be prevented. For symptoms, etc., see p. 1198.

Tuberculous Disease of the Bladder may be primary or secondary, the latter being the more usual, and extending from the kidney, prostate, or testicle. It is much more common in men than in women, and is most frequently seen in young adults. It commences in the submucous tissue as a deposit of miliary tubercle (Plate XIV., Fig. 2), which caseates and suppurates, breaking down, and giving rise to ulcers with undermined edges; these are rarely of large size at first, are usually multiple, and situated in or near the trigone. The **Symptoms** are those of chronic cystitis and hæmaturia, the irritability of the viscus being very marked. The diagnosis is made by demonstrating the bacillus of tubercle in the urine, and by the cystoscope. The course of the case is unfavourable, the ulcers increasing in size, and death resulting from exhaustion, general infection, phthisis, or extension to the kidneys.

Treatment.—The case is usually treated for some time as one of chronic cystitis before its nature as a tuberculous affection is ascertained. In the milder cases it will suffice to attend to the general health and hygiene of the individual, and to wash out the bladder with some antiseptic two or three times a week, leaving a drachm or two of a 10 per cent. solution of iodoform in olive oil or glycerine within the viscus. Injections of tuberculin (p. 184) have been found decidedly valuable in this condition. In more advanced cases cystotomy has been undertaken by the suprapubic method, and the ulcerated surfaces scraped and disinfected by applying the galvano-cautery or pure carbolic acid. To effect this the patient should be placed in the Trendelenburg position, and a suitable speculum used as a caisson through which to work. It is doubtful, however, whether such practice is of much ultimate value. When the primary lesion in kidney or testis is efficiently treated, a secondary bladder trouble often improves.

Very similar **Symptoms** may be induced by the presence of a **Simple Ulcer of the Bladder**, which, according to Fenwick, occurs not unfrequently. It is usually single, and situated near the neck or trigone, giving rise to great irritability of the viscus and hæmaturia, although the urine remains clear. The diagnosis is best made by the cystoscope. Phosphatic deposits sometimes form over the ulcerated surface, and may suggest the existence of a stone. Treatment consists in washing out the bladder with lactic acid ($\frac{1}{2}$ to 3 per cent.), or in scraping and cauterizing the base of the sore through a suprapubic incision.

Tumours of the Bladder.—New growths from the vesical wall are not very uncommon; they may be simple or malignant.

Simple Tumours occur in the form of fibroma, myoma, and myxoma; but that most often seen is the **Papillomatous** or **Villous Tumour,** which appears as a soft flocculent mass, usually situated near the trigone, and close to the opening of one of the ureters (Fig. 548 and Plate XIV., Fig. 4). The floating tufts or villous processes consist of an extremely delicate connective tissue, covered with a layer or two of epithelium similar to that lining the bladder, and traversed by bloodvessels. Occasionally the growths have a narrow base, and are pedunculated, but more frequently are sessile. They may be single, or may multiply rapidly, and spread all over the bladder by infection from the primary growth.

The **Symptoms** are those of recurrent hæmorrhage, the blood being of a bright red colour, followed later on by irritability of the bladder. At first the hæmorrhage is intermittent, considerable intervals occurring between the attacks; but subsequently it becomes more continuous. The irritability of the bladder is generally induced by chronic cystitis, and when the urine has undergone alkaline changes, there is a copious exudation of ropy mucus, which, mixing with the urine, causes considerable difficulty in micturition, leading in some cases to strangury. The urine may also contain portions of the tumour which have been set free, and occasionally, if situated near the neck of the bladder, some of the fimbriated ends may be swept into the urethral orifice, and interfere with micturition. In the same way the opening of one or both ureters may be encroached upon, leading to hydro-nephrosis. On examination of the bladder with a sound, nothing definite can be detected, unless the surface of the growth becomes encrusted with phosphates, and no abnormality is noticed on rectal examination. Occasionally a small portion of the growth may be caught in the eye of a catheter.

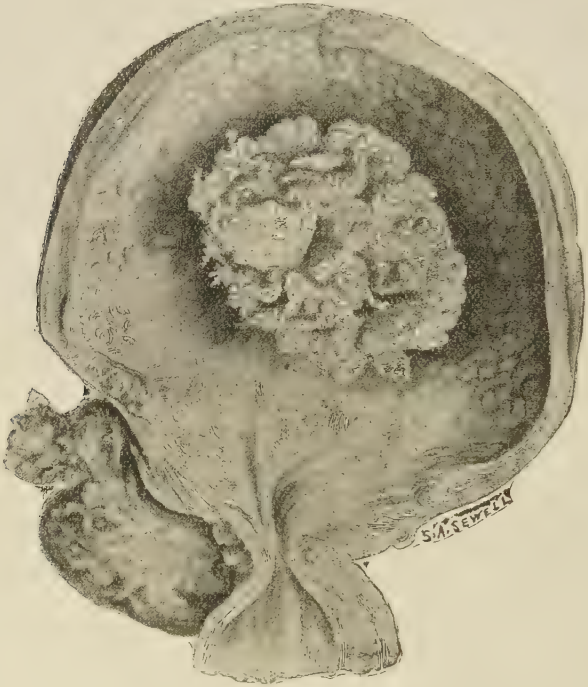


FIG. 548.—VILLOUS TUMOUR OF THE BLADDER. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

The **Prognosis** of the case is unsatisfactory in the absence of effective operative treatment, since, although the tumour is not malignant, it may give rise to multiple growths by tissue implantation, and then their removal is almost an impossibility, and the patients are likely to bleed to death. True malignant disease is said sometimes to supervene, but this is very doubtful. The after-result of operations for a single mass is usually satisfactory.

Sarcoma of the bladder is an uncommon disease, more often seen in children than in adults. In the former it gives rise to multiple polypoid growths; in the latter it is often single and sessile. The tumour grows rapidly, and may attain considerable dimensions spreading outside the bladder, and even invading the pelvic bones. Lymphatic glands may be implicated at an early date.

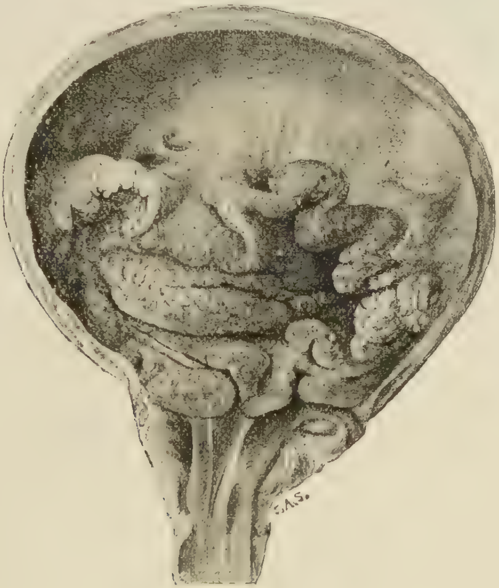


FIG. 549.—CANCER OF THE BLADDER. (FROM ROYAL COLLEGE OF SURGEONS' MUSEUM.)

Cancer of the bladder may originate in that viscus, or may spread to it from the rectum or neighbouring organs. In the former case, the growth is generally a squamous epithelioma; in the latter, its nature is, of course, similar to that of the primary disease; thus, when secondary to rectal cancer, the tumour is of a columnar type. Most frequently the affection commences in the posterior wall above the trigone, extending forwards to the neck of the bladder. The growth is sometimes superficial, projecting into the vesical cavity as a soft spongy mass, which does not ulcerate early, or invade the muscular walls till late; but more frequently the neoplasm extends into and infiltrates the walls, whilst marked ulceration is also present (Fig. 549), the raw surface often becoming coated in places with a phosphatic deposit. A cancerous growth in the bladder is always more or less likely to become papillated. The disease is much more common in men than in women.

The **Symptoms** vary somewhat in these two forms, although the conspicuous features of each are hæmaturia and irritability of the bladder. In the slowly-growing superficial variety, the tumour often attains a considerable size before causing any trouble, beyond possibly some slight irritability of the bladder. A severe attack of hæmaturia, unaccompanied by pain, is usually the first symptom of importance, and may be induced by some injury which causes a crack or fissure in the growth. This painless hæmaturia closely simulates the early symptoms of a simple villous tumour, but is more persistent, and yields less readily to treatment. After one or more of such prolonged attacks, cystitis follows, and the subsequent history resembles that of the harder and more rapidly growing infiltrating tumours. In such, the symptoms of vesical irritability precede those of hæmaturia. Dysuria and severe pain referred to the bladder and perineum are complained of, and the urine early becomes alkaline and putrescent; shreds of the growth may also be found in the urine on microscopic examination. If the tumour involves the internal meatus, micturition may be considerably impaired; whilst if the orifices of the ureters are obstructed, hydronephrosis results. On passing a sound, the tumour can be detected as an irregular mass projecting into the bladder, whilst the posterior vesical wall may be felt *per rectum* to be hard and resistant; its ulcerated surface may also be seen with the cystoscope.

The course of the case is similar to that of a somewhat rapidly growing carcinoma, leading to early and marked cachexia, increased by the sleeplessness resulting from the vesical irritation; secondary deposits are found in the viscera and lumbar glands, whilst perforation of the wall may occasionally follow, causing urinary extravasation, septic cellulitis, and death. Another most distressing complication is the establishment of a recto-vesical fistula, through which the urine makes its way into the rectum, thus intensifying the sufferings of the patient.

The **Diagnosis** of a vesical tumour can only be made with certainty by the cystoscope, or by discovering fragments of its substance in the urine, though in the female it is easy to dilate the urethra, and explore the bladder with the finger. Whenever hæmorrhage is associated with marked vesical irritability, and cannot otherwise be explained, a tumour of the bladder may be suspected, and cystoscopy must be undertaken. In this viscus, as in others, the only hope of curing malignant disease lies in early operation, and if the practitioner waits until the diagnosis is assured by the symptoms, the patient's case is probably hopeless. Early cystoscopy is all-important.

In simple papilloma and the superficial type of epithelioma, hæmorrhage precedes the irritability; but whilst it is usually impossible to detect the villous growth either by examination with the sound, or from the rectum, a fungating malignant growth may sometimes be recognised by the sound. In the infiltrating type of malignant disease, on the other hand, pain and dysuria always precede the bleeding for a considerable interval; whilst definite evidence of the existence of the growth can usually be made out, both by the sound and on rectal examination. A worn and exhausted appearance must not be looked on as necessarily the outcome of advanced cancerous cachexia, since the loss of rest and sleep due to chronic vesical irritability can of itself lead to a somewhat similar condition.

Treatment of Tumours of the Bladder.—In the early stages, when the diagnosis of a tumour has not been confirmed, the hæmaturia may be treated with ordinary hæmostatic remedies, such as a mixture containing dilute sulphuric acid and ergot, or turpentine administered in capsules (10 minims three times a day).

When once a diagnosis has been established, removal by operation is the only plan which holds out any hope to the patient, and this can only be undertaken with any prospect of success in benign growths, or in the very earliest stages of malignant disease. The suprapubic operation is always employed. The bladder is first washed out, and the patient placed in the Trendelenburg position. After opening the bladder and exploring it with the finger, a speculum is introduced and its interior illuminated by an electric lamp fitted to the surgeon's head. If more room is required, one of the rectus muscles may be cut across about 1½ inches above its insertion, and the viscus can then be freely opened.

Papillomata and other simple tumours are removed, together with the mucous membrane from which they grow, by cutting round them with the knife or scissors. The base is ligatured and the growth removed, or a cautery knife may be used for this purpose. The fingers of an assistant in the rectum will suffice to press up the posterior wall and to give support. If possible, the incision in the mucous membrane should be closed by catgut stitches. Where the papillomata are large or multiple, this may involve an extensive operation, but with careful after-treatment there is a good prospect of recovery.

For **malignant disease** of the bladder, partial or complete cystectomy may be possible. **Partial Cystectomy** consists in removal of the whole thickness of the vesical wall involved by the growth, and according to its location this may involve opening the peritoneal cavity or not. The bladder is exposed as described above, and the peritoneum is detached up to and beyond the growth, which is cut away, the solution of continuity in the wall being made good by careful suturing with catgut. **Complete Cystectomy** has been undertaken for extensive malignant disease, and may include removal of the prostate and seminal vesicles, the scope of the operation extending nearly to the membranous urethra. Necessarily, preliminary arrangements have to be made as to the ureters. Three plans are feasible: (1) They are implanted into the rectum, and the patient must run the chance of an ascending pyelonephritis; (2) the ureters are brought out of incisions in the loin and drained; or (3) a double nephrostomy is performed, and the pelvis drained on either side, the patient then experiencing the discomfort of a double urinary fistula. The subsequent operation of removing the bladder is not one of extreme difficulty, but requires care to protect the patient from hæmorrhage and from infection of the peritoneal cavity.

When removal is impracticable, it only remains to ease the patient's sufferings by means of morphia, the bladder also being occasionally washed out; but if the irritability is very great, a permanent suprapubic or perineal opening may be established.

Stone in the Bladder.

Varieties.—A vesical calculus may be formed of almost any of the urinary deposits commonly met with, and each has its own special characteristics.

(*a*) The *uric acid* calculus (Plate XV., 1 and 2) is usually an oval, flattened body of considerable density, with a smooth or slightly nodular surface, and of a nut-brown colour. On section it is distinctly laminated, and it may be surrounded by a crust of phosphatic material.

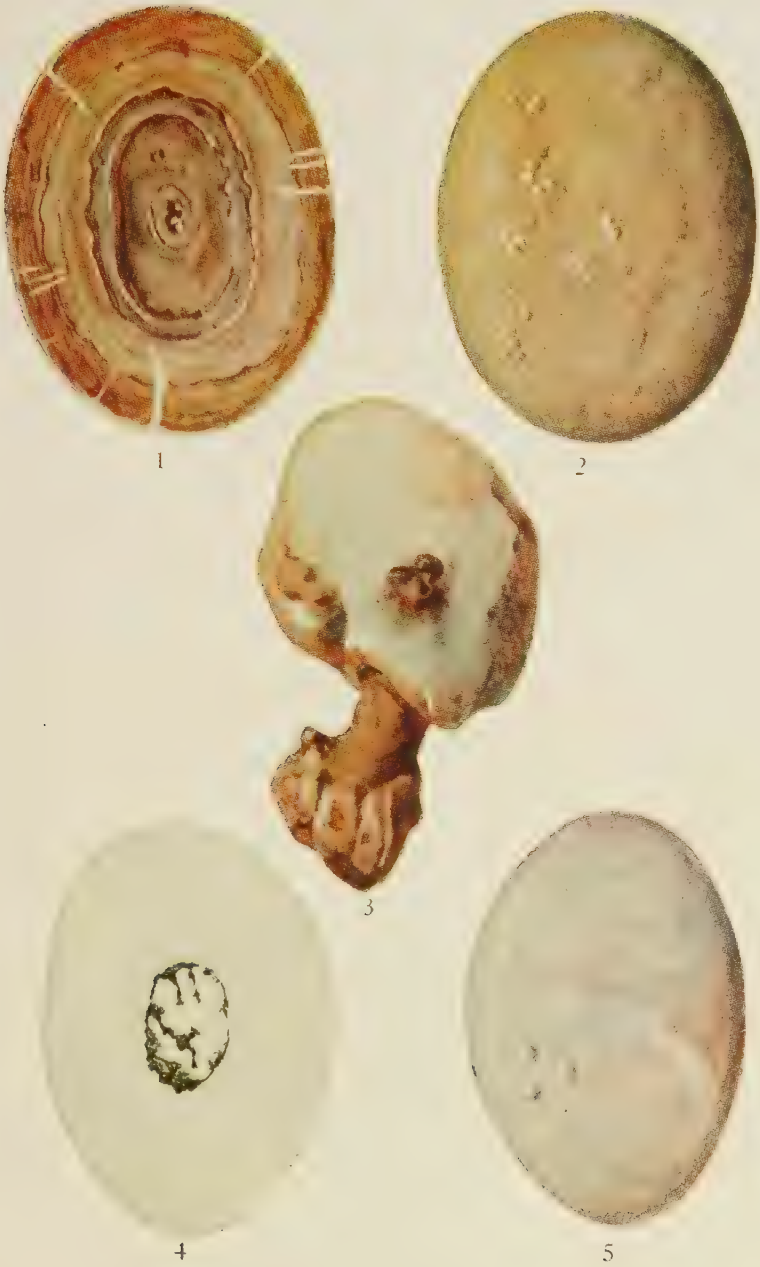
(*b*) The *urate of ammonium* calculus is of very similar structure, but of a lighter colour, and the lamination is less distinct.

(*c*) The *oxalate of lime* or mulberry calculus (Plate XVI.) is a rough, irregular body, sometimes evenly nodular, but not unfrequently tuberculated, or even spiculated. It is extremely hard and dense, laminated, and of a dark red-brown colour, or sometimes black, owing to admixture with blood. It is rarely of great size, on account of the irritation caused by its presence, and its slowness of growth.

(*d*) A pure *phosphatic* calculus (Plate XV., 4 and 5) is very uncommon, but any stone or foreign body is certain to become coated with a phosphatic deposit when chronic cystitis has resulted in alkaline decomposition of the urine. Occasionally concretions of a similar nature form spontaneously in saccules of the bladder; such bodies are white and chalky in appearance, friable in consistency, with no evidence, or but little, of lamination, and on removal are exceedingly offensive. These concretions consist of a mixture of the triple phosphate and phosphate of lime. Less commonly an excess of the triple phosphate is present; if in the proportion of two parts of the latter to one of phosphate of lime, a laminated and somewhat denser calculus is produced, which is sometimes termed a *fusible calculus*, owing to the fact that it fuses to a bead under the blowpipe flame. Occasionally a phosphate of lime calculus occurs in the upper urinary passages (*e.g.*, the pelvis of the kidney), and has a crystalline appearance on drying.

(*e*) *Cystine* forms the basis of a rare calculus which is of a yellowish-green colour and waxy appearance.

PLATE XV.



Stones from the Bladder.

Figs. 1 *and* 2.—Uric acid Calculus—on section and outer surface. *Fig.* 3.—Encysted Calculus of uric acid. The lower segment was held firmly in a saccule near the trigone; the larger portion projected into the bladder. A certain amount of phosphatic deposit covers the exterior. It was successfully removed by a suprapubic operation. *Figs.* 4 *and* 5.—Phosphatic Calculus.

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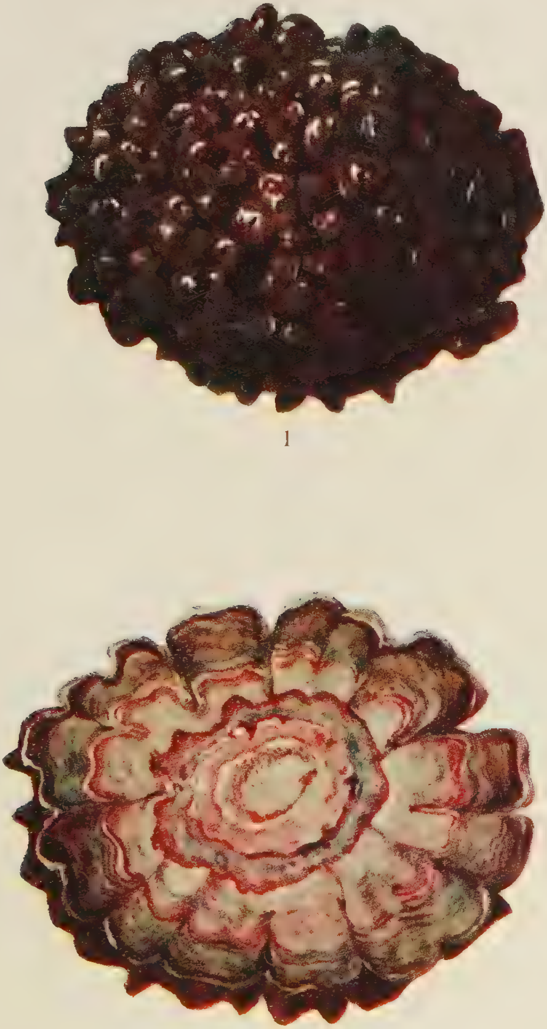
PLATE XVI.



Oxalate of Lime Calculus.

Fig. 1.—From the exterior. *Fig.* 2.—On section.

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(*f*) *Xanthine*, or xanthic oxide, occurs very exceptionally as a calculus of a reddish colour.

An **encysted** calculus is one which develops in a pocket or pouch connected with the bladder wall. It may consist of any of the above substances, and is due to a small stone finding its way into a saccule and being arrested there. It grows by gradual accretion of new calculous material, and after a time projects into the vesical cavity. A typical illustration is shown in Plate XV., 3, where the large intravesical portion is separated from the encysted part by a narrow neck. Occasionally this condition is due to the decomposition of stagnant urine in a pouch, and the calculus is then phosphatic in composition; it is not unlikely to lead to ulceration of the sac wall and extravasation of urine.

Structure of a Calculus.—A calculus usually consists of the following parts: 1. The *nucleus*, which may be formed by a portion of blood-clot, inspissated mucus, a renal calculus, or some foreign substance introduced from without. 2. The *body*, which consists of superposed layers of uric acid or oxalate of lime, or of whatever substance the stone is composed; not unfrequently the composition of adjacent laminæ differs, leading to what is known as an *alternating calculus*. Each lamina consists of myriads of minute crystals, held together by vesical mucus, with which a certain amount of phosphatic material is often mixed, whilst layers of pure phosphatic deposit may be interposed. 3. The *crust* consists of a variable amount of soft, friable phosphatic material, the quantity of which is the measure of the degree of chronic cystitis originated by the calculus; in some cases it is entirely absent.

The **Number** of calculi present in a bladder varies greatly. Sometimes there is only one; occasionally a considerable number, counted perhaps by hundreds, may exist; in such circumstances they are never of great size. Multiple calculi are not unfrequently faceted as a result of mutual friction.

The **Causes** of vesical calculus must be looked for in some of those constitutional conditions already described as predisposing to lithiasis or oxaluria. They are very common in children during the first decade of life, especially amongst the lower classes, the children of the rich rarely suffering from stone. It diminishes in frequency from childhood to the age of twenty-five, and then gradually increases until it is relatively common in elderly men. The condition is comparatively rare in women, owing to the fact that the shortness and large size of the urethra allow small calculi to be much more readily passed. Possibly the character of the drinking-water, or the amount imbibed, is a matter of importance, as indicated by the fact that the occurrence of calculus is very unequally distributed in different parts of the country; thus, it is most frequently met with in the Eastern Counties. It is also very common in India and Arabia, a fact which may possibly be explained by the large amount of fluid withdrawn from the body by perspiration.

Symptoms.—The effects produced by vesical calculi vary in different individuals, according to the shape of the stone, and the tolerance of the mucous membrane. In children and young adults, where the parts are very sensitive, even a smooth calculus gives rise to severe symptoms, whilst old men often tolerate a large stone without much inconvenience; *cæteris paribus*, an oxalate of lime calculus is always more irritating than one composed of uric acid. The classical symptoms of a vesical calculus may be preceded by a history of the patient having passed 'gravel' for a long time, or by an attack of renal colic, on the cessation of which the calculous symptoms commenced. Sometimes the vesical symptoms do not appear for some time after the passage of a stone into the bladder. presumably in consequence of its small size. They consist of pain in the perineum and neck of the bladder, which radiates to the back and down the thighs, but is especially noticed at the end of the penis immediately after micturition. The stone is then pressed down against the sensitive neck of the bladder by the contraction of its muscular walls. Increased frequency of micturition is also present, and perhaps hæmaturia of a vesical type, though this is not a prominent feature. All these phenomena are increased in severity by jolting, jumping, or any form of exercise, and hence are more marked during the day than at night. Occasionally the patient complains that the flow of urine suddenly ceases before the bladder has been completely emptied, and that some change in the position of the body is needed in order to allow him to complete the act. In addition to these characteristic symptoms, he may suffer from various phenomena secondary to the irritability of the bladder, and dependent on the straining induced by the calculus. Thus, tenesmus, followed by piles or prolapsus ani, may be produced by sympathetic irritability of the rectum, especially in children; whilst a hernia may also be caused, and not unfrequently priapism.

The symptoms are somewhat modified in *children*, leading to irritability of the bladder, as evidenced by wetting of their clothes and of their beds at night, and pulling at the prepuce and penis. These manifestations are very similar to those caused by a tight foreskin, with which condition, indeed, a stone is often associated; hence, it is important always to sound the bladder of a child after circumcision for phimosis.

The actual **Diagnosis** of vesical calculus can be made by radiography or sounding. *X-ray* examination is conducted in the usual fashion, care being taken to see that the rectum is empty. The lamp is placed over the patient's abdomen, with the rays directed downwards and backwards, and the plate is behind. The calculus usually appears as a shadow immediately above the pubic rami (Fig. 550). In order to examine a patient by *sounding*, he is laid on a couch with the head low, and the buttocks raised on a pillow placed beneath them. The bladder should always contain a few ounces of fluid, so as to obliterate any folds produced by laxity of the mucous membrane, as well as to facilitate the introduction of the instrument; the usual antiseptic precautions as to surgeon's hands, patient's penis, instrument, and lubricating material, are of course rigidly enforced. A sterilized sound of suitable size, warmed and lubricated by some antiseptic preparation, is then gently passed along the urethra, and the handle depressed between the separated legs so as to enable the point to enter the bladder. The handle, which should be cylindrical in shape and fluted, with the maker's name or some mark to indicate the direction of the beak, is then lightly grasped between the index-finger and thumb, and rotated from side to side, whilst at the same time the whole instrument is drawn forwards or backwards in the urethra. Each side of the bladder is thus carefully investigated, and, finally, if no stone is detected, the beak is turned directly downwards, so as to examine the pouch which often forms behind a slightly enlarged prostate. The presence of a stone is recognised by a metallic click, which can be felt and even heard, when the end of the instrument taps it. The character of the click is some guide to the size and density of the stone. The presence of two or more calculi is indicated by the surgeon being able to touch them on rotating the instrument alternately to each side of the middle line, or by seizing one stone with a lithotrite, and using it as a sound for the other. In doubtful cases, a still more delicate test than the sound is obtained by passing a

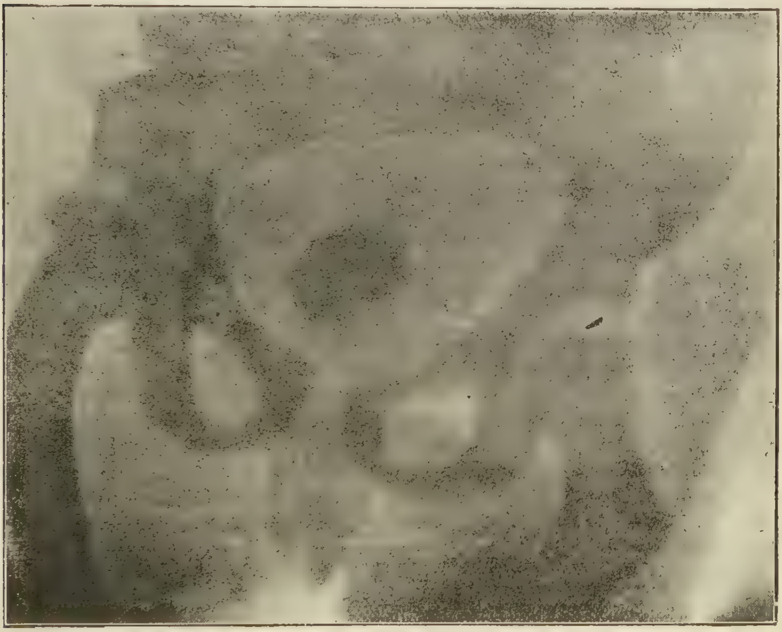

FIG. 550.—RADIOGRAM OF VESICAL CALCULUS IN A BOY.

medium-sized tube of a Bigelow's evacuator, and washing out the bladder. The calculi may by this means be sucked out even from sacculi, and be felt to rattle against the end of the instrument when the pressure upon the indiarubber bulb is relaxed. When the calculi are multiple and of small size, they may be even removed in this way by an examination which was only intended to be diagnostic in character. The surgeon must not forget that a hypertrophied bladder with projecting fasciculi may somewhat resemble a calculus, especially when coated with phosphatic material. In some rare instances a calculus may be so completely hidden in one of the saccules as to render its detection impossible by these means. An encysted calculus which projects into the bladder is recognised by being always found at the same place.

Course of the Case.—A patient suffering from vesical calculus is certain, sooner or later, to develop symptoms of chronic cystitis, and septic changes in the urine are equally sure to follow—possibly as a natural sequence, but often as the result of the introduction of dirty instruments. The bladder is hypertrophied, and if the stone is not removed, the mucous membrane becomes ulcerated, and the inflammation extends to the kidneys; the patient's life is thus destroyed, partly by exhaustion, and partly by septic or uræmic poisoning.

The **Treatment** of vesical calculus is a matter which has exercised the judgment and manipulative dexterity of surgeons for many centuries. A large number of operations have been made use of, but at the present day only three are employed—viz., lithotrity, suprapubic cystotomy, and very uncommonly perineal cystotomy.

Lithotrity was formerly conducted in several stages, the stone being crushed, and the patient allowed to pass the débris subsequently; this process was repeated at intervals of a few days, until the bladder was clear. Such a proceeding took a considerable time, and was exceedingly painful, irksome, and dangerous to the patient. The introduction of Bigelow's evacuator completely revolutionized this operation, and enables it to be completed at one sitting, constituting the proceeding sometimes termed Litholapaxy.

Operation.—The patient is carefully prepared by keeping him under observation for a few days, regulating the bowels, and, if possible, reducing any inflammation of the bladder by suitable diet and drugs, and by washing it out. On the preceding night a dose of castor oil is administered, and an efficient enema a few hours before the operation. The patient should be warmly clad, and the legs enclosed in thick worsted stockings reaching nearly to the groins. After anæsthesia has been induced, the head is kept low, and a pillow placed beneath the buttocks, so as slightly to raise the pelvis. The bladder is carefully washed out with some bland antiseptic, such as a solution of boric acid, and about 6 ounces of lotion are left within it, in order not only to obliterate all folds of mucous membrane, but also to facilitate the seizure of the stone, and to prevent injury of the walls during the operation.

The lithotrite (Fig. 551) is then introduced. The male blade slides easily up and down a groove in the stem of the female blade, and after the stone has been seized the blades are forcibly pressed together by a screw action, brought into play by the mechanism in the handle, which can be put in and out of gear at will. It is absolutely essential that the instrument should be made of well-tempered steel, so as to prevent any risk of breaking during the operation. To introduce it some skill is needed, since the curved end is short, and consequently the handle must be well depressed between the legs, in order that the beak may pass under the pubic arch. The position of the stone is next ascertained by rotating the instrument, and using it as a sound; the blades are opened, and the stone caused to roll between them by a slight jerk of the handle. This is better than attempting to pick up the calculus by inverting the blades, and is less likely to injure the mucous membrane. If fairly grasped, the blades when screwed up crush it into several fragments, each of which is subsequently dealt with in a similar fashion. If only the margin of the stone is gripped, the application of screw pressure may cause it to slip away, and the manœuvre must then be carefully repeated. When the surgeon is satisfied that the fragments are sufficiently small, the largest evacuator-tube that can be safely introduced is passed into the bladder. To effect this, it is sometimes necessary to incise the urethral orifice with a bistoury in a downward direction. The evacuator is attached to the tube, and the bladder thoroughly washed out by alternate pressure upon, and relaxation of, the rubber bottle (Fig. 552). By this means the fragments of the stone are collected in the glass receptacle which forms part of the apparatus. The washing is continued until no more fragments are heard or felt to rattle against the end of the tube. It is often necessary to reintroduce the lithotrite in order to crush some larger portions of the calculus still remaining; the old practice of withdrawing small fragments within the grasp of a lithotrite is to be condemned. It is scarcely necessary to re-sound the bladder after the efficient use of the evacuator. A certain amount of bleeding is indispensable from these manipulations, but it is not excessive in careful hands Should, however, considerable bleeding follow, the

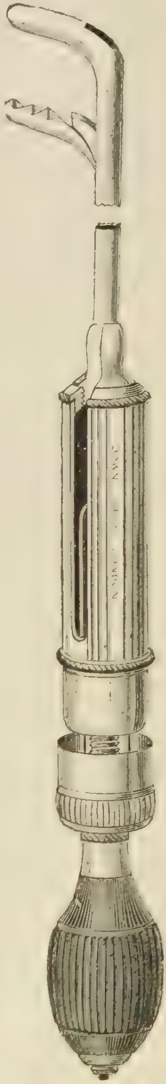

FIG. 551.—THOMPSON'S MODIFICATION OF CIVIALE'S LITHOTRITE. (DOWN BROTHERS.)

bladder is likely to become subsequently distended with clots, necessitating the use of a large-eyed catheter for their removal.

After-Treatment.—The patient is placed in bed as soon as the operation is completed, and kept warm and quiet, and suitable measures must be taken to combat shock. The diet is restricted to fluids for a few days, whilst pain, if complained of, may be relieved by a little morphia. If all goes well, he may be allowed to get up at the end of the week.

Various **Sequelæ** may follow this operation. *Cystitis* results partly from mechanical causes, but more frequently from imperfect asepsis. The symptoms are usually subacute in character, and may pass away after a few days; but if of a serious type, considerable constitutional disturbance arises, and a large amount of viscid muco-pus is excreted, whilst the urine becomes alkaline and ammoniacal. In such a case it is absolutely essential to wash out the bladder once or twice a day, as if left to itself the condition is very liable to spread up to the ureters, and may destroy the patient's life by suppurative pyelonephritis. *Atony of the bladder* is occasionally induced, either by the operation or by a consequent cystitis, and is especially common in elderly individuals. It must be treated by regular and aseptic catheterism. When the patient's kidneys are already affected prior to the operation, an acute ascending pyelonephritis (p. 1198) may be originated by it, perhaps leading to suppression of urine and death from uræmia.

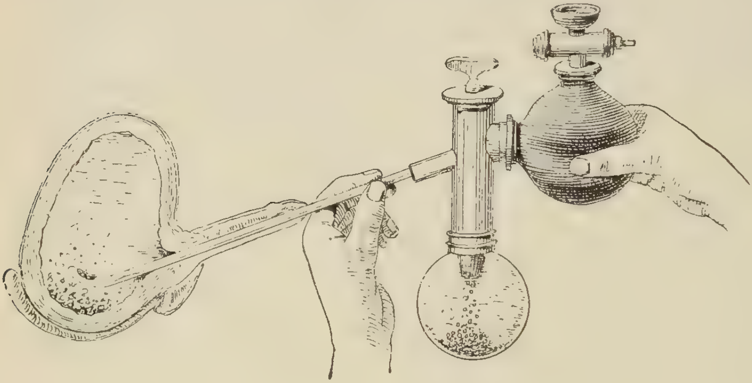

FIG. 552.—EVACUATOR IN POSITION IN THE BLADDER.

Suprapubic Lithotomy was formerly looked on as a serious procedure with a high mortality; at the present time increasing experience has shown that the dangers were preventable, and that it may be considered a very successful procedure. The bladder is washed out, and 8 or 10 ounces of lotion left within it; the patient is then placed in the Trendelenburg position, with the pelvis raised, the intestines being thus allowed to gravitate to the postero-superior part of the abdomen; as soon as the abdominal parietes are opened, air finds its way into the connective tissue behind the symphysis (cavum Retzii), and the peritoneum is thus pressed back.

Operation.—The pubes having been previously shaved, and the hypogastrium purified, an incision is made in the median line reaching from the top of the symphysis upwards for about 2 or 3 inches; the lower part of the linea alba is divided, and the retropubic cellular tissue opened up. The tense rounded outline of the bladder can now be readily detected with the finger, and a couple of lateral silk sutures or slings are passed through its walls so as to steady it and prevent its subsequent retraction. An opening is then made into it in the middle line from below upwards, through which the index-finger is passed and the stone examined. Suitably curved lithotomy forceps are introduced, and the stone grasped and withdrawn. A careful examination of the interior of the bladder is made, to ascertain whether any further calculi are present, as also to investigate the condition of the prostate, which may sometimes be advisably removed at the same time. The after-treatment of the wound differs with the condition of the bladder; if it is infected, a good-sized drainage-tube is introduced, and the urine syphoned off, healing occurring by granulation in three to six weeks (see After-Treatment of Prostatectomy, p. 1251). If the bladder is healthy and free from infection, it may be closed by sutures, which only pass through the muscular and submucous coats, and thus when tied do not project into its cavity. The external wound may then be left open or closed, except at the spot where a drainage-tube or gauze wick is passed down to the vesical wound, so as to allow exit to any urine which may accidentally leak into the wound. The urine is either drawn off by a catheter at regular intervals, certainly not less than three or four times daily, or the bladder is drained by tying in a catheter.

Perineal Lithotomy is seldom required at the present day; the procedure described as perineal cystotomy (p. 1223) would be adopted. The finger is passed into the bladder, and the stone located. It is removed by suitable stone forceps, or by a scoop and the finger. Care must be exercised not to damage the structures at the neck of the bladder, or pelvic cellulitis may ensue; but this danger is little likely to arise, as the operation ought never to be undertaken when the stone is of large size.

Formerly much importance was attached to the operation of *lateral lithotomy*, in which the stone was removed through a perineal incision which included the left lateral lobe of the prostate. This procedure is now entirely superseded, and need no longer be described.

Choice of Operation for Vesical Calculus.—At the present day lithotrity has been brought to such a standard of excellence that there is no doubt as to the general rule which should be followed—viz., that *unless some contra-indication is present, all cases of vesical calculus should be treated by lithotrity.*

The **Contra-indications to Lithotrity** are as follows: (1) *Conditions of the Stone.* If the calculus exceeds 1½ inches in diameter, it is not advisable to attempt lithotrity, on account of the damage which may be inflicted on the vesical wall. Moreover, some stones, especially those consisting of oxalate of lime, are so hard that no lithotrite can crush them. Phosphatic concretions, on the other hand, are so soft that a lithotrite becomes clogged, and crushing is impracticable. An encysted stone will also preclude lithotrity on account of its fixed position. There is no objection to dealing with multiple calculi by this means, but if only of small size, they may be removed by simply using the evacuator. (2) *Conditions of the Urethra.* The existence of an organic stricture, or an enlarged prostate, may render lithotrity impracticable from the impossibility of passing large enough instruments, whilst false passages may make it exceedingly difficult. Excessive irritability of the urethra, as evidenced by the occurrence of severe rigors after instrumentation, may also render the operation unadvisable. (3) *Conditions of the Bladder.* The existence of severe cystitis or the presence of sacculi, as indicated by the cystoscope, will usually suggest the performance of lithotomy; whilst a contracted bladder, which will only hold a few ounces of urine, materially increases the dangers and difficulties of lithotrity.

Suprapubic Lithotomy should be undertaken under the following conditions: (1) Where the stone is too large to be dealt with by crushing; (2) where the stone is encysted; (3) where a stricture or enlarged prostate is present, and it is often feasible to remove the prostate at the same time. Suprapubic cystotomy is only absolutely contra-indicated by two conditions—viz., severe septic cystitis and contraction of the bladder.

Indications for Perineal Lithotomy.—(1) When serious cystitis and great irritability of the bladder are present, the incision facilitating the process of draining and washing it out; (2) a contracted and hypertrophied condition of the bladder; (3) when a calculus is impacted in the neck of the bladder.

Calculus in Boys is a common occurrence. It must be remembered that the bladder is rather an abdominal than a pelvic organ in children, and hence suprapubic lithotomy is particularly indicated, except in the hands of skilled lithotritists. It has been shown, however, that lithotrity can be safely practised, and many surgeons in the East, where stone is so common, employ it as a routine procedure, granting that a No. 6 catheter can be passed, and that the stone is not too large for a lithotrite to grasp. Special lithotrites and evacuators are constructed for the purpose.

Calculus in the Female.—As already mentioned, vesical calculus is very rare amongst women, owing to the shortness and greater size of the urethra, so that small stones passing downwards from the kidneys are easily voided. Phosphatic concretions are not uncommon, and are then formed around a foreign body usually introduced by the patient. Many of the symptoms are very similar to those in the male. **Treatment.**—If the calculus does not exceed $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter, it can usually be extracted by dilating the urethra with the finger, the sphincter being also nicked in two or three places if necessary. It is never wise to divide the sphincter totally, as incontinence is almost certain to follow. For a somewhat larger stone lithotrity can be undertaken, whilst for those of really large size suprapubic cystotomy is the best procedure. It has been recommended to open the bladder through the anterior vaginal wall, and thus remove a stone; but this is scarcely desirable, for fear of the persistence of a vesico-vaginal fistula.

Functional Derangements of the Bladder.

The act of micturition is a complicated proceeding, which for its effective performance requires the due co-ordination of several factors. When urine collects in the bladder, it is prevented from escaping at once by the tonic contraction of the sphincter vesicæ; in infants this is but little developed, and hence is readily overcome by the relatively strong detrusor in response to but slight intravesical pressure. As the child grows, the sphincter becomes better developed, and is under more effective control; whilst at puberty the growth of the prostate adds to this, and therefore micturition loses its reflex character, and becomes entirely voluntary. Three chief elements enter into the act of urination —viz., (1) an appreciation of the stimuli set up in the bladder by its increasing distension, which depends on the sensory nerves having a free communication with the sensorium; (2) as a result of this stimulus, the sphincter vesicæ is voluntarily inhibited; and (3) the detrusor muscle is contracted, expulsion of the urine necessarily following. A voluntary contraction of the abdominal muscles is often employed to assist in this expulsive effort. Each of these muscular elements has its own centre in the lumbar enlargement of the spinal cord, and it is possible for one or both of them to be destroyed or weakened. Should the sphincteric control become weak, the activity of the detrusor may be relatively increased, and the bladder contents are expelled too frequently (active incontinence). Should the sphincteric control be relatively increased, the expulsive efforts of the detrusor will be hindered, and retention results. Necessarily other causes than nervous enter into the production of these two conditions, and hence they must be considered separately.

Incontinence of Urine.—A patient is said to be suffering from incontinence when the urine escapes involuntarily, dribbling away either constantly or intermittently from the urethra.

1. **Active Incontinence** (**Enuresis**) is often present in young children, mostly boys, in whom, as already indicated, sphincteric control is not too well developed. It results from some condition of increased excitability of the urinary apparatus, and is looked on by some as of a choreic nature. The chief sources of irritation are phimosis, ascarides in the rectum, a rectal polypus, or urine of high

specific gravity, containing uric acid crystals in suspension. The affection is most obvious at night, and, indeed, may only occur during sleep; it usually disappears when adult life is reached, if not cured before, but has been known to persist later. **Treatment** of the nocturnal incontinence consists in the removal of all sources of irritation—such as a tight foreskin; whilst the child is waked from sleep at regular intervals in order to pass water, so as to break him from the bad habit. Tonics—*e.g.*, iron, arsenic, and quinine—may be administered, and tincture of belladonna should also be given in full doses. He must not be allowed to lie on his back, or to eat or drink late at night, but must be kept warm. All excitement of the sexual senses must also be avoided.

2. **Passive Incontinence** is said to be present when the neck of the bladder is relaxed, so that as soon as any urine is secreted, it flows out of the urethra—the bladder in this way never becoming distended. It arises mainly from two causes: (*a*) *Paralysis* of the sphincter vesicæ, as a result of some injury or disease of the spinal cord, which may impair its function either temporarily or permanently. Thus, in severe shock, the bladder is unconsciously evacuated from relaxation of the sphincter; but if the lumbar cord is not compressed or destroyed, the function is soon regained. Any lesion involving the centre for the sphincter necessarily destroys its future utility, and results in permanent incontinence. It is quite possible for the detrusor centre to be damaged without injury to the sphincter, and in such a case distension of the bladder with subsequent overflow supervenes. Paralytic incontinence occasionally follows overdistension of the female urethra for the removal of a calculus. Nothing can be done for either of these conditions, if permanent, beyond the application of a suitable urinal. (*b*) *Mechanical Incontinence* sometimes results from the impaction of a calculus in the internal meatus, or from its dilatation by a pedunculated growth from the prostate.

3. **False Incontinence,** or **Distension with Overflow,** may be the outcome of an attack of retention, naturally relieved, or is due to any condition in which the outflow of urine is impeded to such an extent as to lead to a certain quantity being left in the bladder after every act of micturition, although the patient imagines that the organ has been completely emptied. This so-called *residual urine* gradually increases in amount until the bladder becomes filled, and then some of it dribbles away involuntarily so as to wet the patient's clothes. In old-standing cases the bladder can be detected as a tense, rounded swelling in the hypogastrium. This condition is usually met with in patients with neglected stricture or enlargement of the prostate, and in the latter case the bladder may be so distended as to contain many pints of urine. Very much the same state of things obtains in paralysis dne to spinal mischief. Treatment must be directed to keeping the bladder emptied by the regular use of a catheter, but it often remains in an atonic state for some time.

Retention of Urine.—When a person is unable to expel the contents of his bladder, so that it becomes distended, retention is said to be present. It results from a variety of conditions, which may be classified as follows:

1. *Mechanical obstruction* which may involve any part of the urethra or the neck of the bladder, the actual cause varying somewhat with the age and condition of the patient. Thus, in infants the commonest cause of retention is the narrowed orifice of a tight phimosis; in children, an impacted calculus in the urethra or a ligature tied round the penis; in young men, gonorrhœa or one of its complications; in young women, foreign bodies in the urethra or bladder; in adult men, stricture; in adult women, uterine fibroids or some uterine condition compressing the bladder or urethra; and in old men, hypertrophy of the prostate.

2. *Nervous lesions* may be responsible for some cases. Anything that excites the sphincteric energy or diminishes the activity of the detrusor muscle may determine retention, and thus it may be brought about in many ways: (*a*) Spasm of the sphincter may result from mental perturbation or excitement, a person being unable to micturate in the presence of others; possibly this is more evident in those who have been guilty of masturbation. (*b*) Neurosis is a common cause, as in hysteria or shock; whilst a reflex neurosis is responsible for retention after injuries or operations, especially when the latter are somewhere in the neighbourhood of the genital organs, as for piles, hernia, varicocele, etc. (*c*) Organic disease of the nervous system produces retention, as in tabes, disseminated sclerosis, traumatic and neoplastic conditions of the cord, etc.

3. Inflammatory diseases of the bladder may be followed by difficulty in micturition or even retention, probably as the result of an interstitial fibrosis of the vesical wall, and may, perhaps, occur most frequently after gonorrhœal cystitis, or that due to the *B. coli*.

4. Retention is sometimes the outcome of habit or circumstances, as in clerks or school teachers, and then when the opportunity to micturate occurs the act cannot be completed.

If left unrelieved, the urine accumulates and the bladder becomes distended, as described at p. 1215, giving rise to much pain and discomfort. One of two conditions is certain to follow: (*a*) In cases of retention from stricture, or when a calculus is impacted in the urethra, the dilated urethra behind the seat of obstruction gives way, resulting in perineal *extravasation* of urine. If, however, the vesical bladder wall has been weakened as the result of ulceration, or if it be sacculated, rupture of that viscus may occur, and pelvic extravasation may follow. (*b*) When the retention is not due to complete obstruction of the passages, the distention is in time followed by unconscious *overflow*, and relief is thereby obtained, although the bladder wall passes into a condition of atony.

The treatment of retention necessarily varies with the cause, as it is but a symptom.

Atony of the Bladder is the term applied to a condition in which the patient is unable to expel the contents, not on account of any true paralysis, but simply from loss of tone of the muscular wall. The causes are as for retention, and the condition may be determined by a single act of over-distension, or be the outcome of a more chronic type of retention. Thus, owing to the oversight of a house-surgeon, it occurred in a patient who had been operated on for varicocele, and left unrelieved for twenty-four hours. More commonly, however, it is met with in old people who are suffering from retention due to enlargement of the prostate, or in men who are the subjects of stricture of the urethra.

In the slighter cases all that is noticed is some hesitation or difficulty in commencing the act of micturition, whilst the flow itself is weak, the urine escaping with no force, and often dribbling away after the act is apparently completed. In bad cases a considerable amount of residual urine may be left in the bladder, the decomposition of which may lead to chronic cystitis. The **Treatment** should be directed to removing any source of obstruction which exists, whilst regular catheterism two or three times a day will prevent any distension of the bladder, and the administration of strychnine, phosphoric acid, and other tonics, will improve the expulsive power of the viscus. The passage of a constant current of electricity may also be employed two or three times a week, to stimulate the muscular fibres; one electrode is inserted into the bladder, and the other placed over the hypogastrium.

Affections of the Prostate.

Acute Prostatitis arises most usually as a sequela of gonorrhœa, either in its acute or chronic stage, by direct extension backwards of the inflammatory process; it is also occasionally met with as a result of stricture arising from the irritation of retained and decomposing urine, or from the passage of instruments. It is said to be induced by the application of cold or damp to the perineum, as by sitting on cold stones or damp grass, but probably this has been preceded by bacterial invasion of the posterior part of the urethra. Suppuration follows in not a few cases, being due to the infection of the prostatic follicles with pyogenic organisms. Sometimes merely one or two superficial follicles are affected, causing what is termed a *follicular abscess ;* occasionally the mischief extends much more widely, involving the whole of one lobe, or perhaps the whole organ, and constituting a *parenchymatous abscess.*

The **Symptoms** consist of deep-seated pain referred to the neck of the bladder, with perhaps a sense of weight and fulness about the perineum, and pain referred to the end of the penis. Micturition becomes frequent and painful, and defæcation may cause considerable distress. As the organ increases in size, the pain becomes more and more severe, and all movements of the body, as also the act of sitting, are increasingly difficult. On rectal examination the organ can be felt enlarged, hot, and tender. Suppuration is likely to follow, and retention of urine may be thereby induced. A follicular abscess bursts into the urethra spontaneously, or is ruptured by the passage of a catheter for the relief of retention; the opening, however, is sometimes of a valvular nature, and only a small portion of the pus escapes. The process may then continue to spread, and the pus may find its way into the rectum, or come to the surface through the perineum. In either of the latter conditions a rectal or perineal fistula is liable to result. Considerable constitutional disturbance, and perhaps a good deal of fever, are usually associated with this affection, whether suppuration occurs or not. The formation of a parenchymatous abscess is always attended with much more acute symptoms, both general and local. The organ is larger and produces more rectal irritation; a considerable quantity of pus may form, and suppuration may extend beyond the capsule into surrounding parts.

Treatment.—The patient should be kept in bed on a restricted diet, and the bowels freely opened by saline purges, combined with small doses of antimony, and perhaps full doses of hyoscyamus. Local depletion may be undertaken by cupping the perineum, or by applying ten or twelve leeches to it. Hot hip-baths are also very valuable, and linseed-meal poultices may be placed on the perineum after the leeches have been removed. Extreme pain should be relieved by the use of morphia suppositories, and if the urine needs to be drawn off, a soft rubber catheter of small size should be used. If an abscess forms, and is not opened by the passage of a catheter, or if the natural opening is of a valvular character, so that the cavity cannot completely empty itself, an incision must be made into it through the middle line of the perineum, being guided by a finger placed in the rectum; pus may not be reached until the knife has entered to a depth of about 2 inches. Urine will sometimes escape from this opening, and may continue to do so for some considerable time. If gonorrhœa is also present, suitable treatment must be adopted in order to check the discharge. When the abscess is pointing in the rectum, it may be wise to open it from that cavity; but every effort must be made to avoid this contingency, as a recto-urethral fistula may result.

Chronic Prostatitis is perhaps one of the most common causes of chronic gleet after gonorrhœa. It is sometimes left as a sequela of an acute attack, or may arise as a result of stricture.

The **Symptoms** produced by it are a sense of weight and fulness about the perineum, combined with irritability of the bladder, and pain referred to the extremity of the penis at the end of micturition, owing to the bladder contracting upon the hyperæmic and sensitive organ. A glairy discharge of viscid material, similar in appearance to uncooked white of egg (*prostatorrhœa*), is often present, whilst fine threads of mucus are usually seen floating in the urine, being due to the formation of mucous casts of the prostatic ducts. On examination through the rectum, the organ can be felt enlarged and tender, and the vesiculæ are usually in the same condition. Chronic suppuration may follow, the abscess bursting into the urethra or rectum, or pointing in the perineum.

The **Diagnosis** from tuberculous disease can usually be made by careful attention to the history and physical signs.

Treatment consists in counter-irritation of the surface of the perineum, as by blisters or iodine paint, care being taken that the reagent employed does not extend either to the anus or scrotum. Belladonna suppositories may be of value, whilst the occasional passage of a cold metal bougie may do good. In suitable cases, where a long-standing gleet is present with no suspicion of suppuration, a cure may occasionally be brought about by the administration of iodide of potassium, or of the liq. ferri perchloridi (♏xv. or more, t.d.s.), combined with sulphate of magnesia. The local application of a solution of nitrate of silver by a porte-caustique is also sometimes recommended, but probably the best treatment consists in forcible dilatation of the prostatic urethra, as suggested by Oberländer, the follicles being thereby emptied of their secretion; massage of the prostate *per rectum* against a sound held in position may also be useful. Should an abscess form, it is incised through the perineum.

Tuberculous Disease of the Prostate is usually met with as a result of extension from similar disease in the epididymis, the seminal vesicles being also invaded; occasionally, however, it may arise as a primary affection. In either case, it rapidly spreads to the bladder, and thence to the ureters and kidneys. The prostate is found to contain caseous masses in the early stages, but later on these break down, leading to extensive ulceration, and sometimes the organ is riddled with ragged cavities. The symptoms are those of irritability of the neck of the bladder, combined with pain referred, perhaps, to the end of the penis, or mainly noticed in the back or perineum. Hæmaturia is occasionally produced, whilst pyuria is almost constant. The urine is feebly acid or neutral, and, on examination of the pus which is deposited on standing, the tubercle bacillus may be detected. Rectal examination will demonstrate an irregular enlargement of the organ, whilst if the vesiculæ are invaded they can also be felt.

Treatment consists in attending to the general health, and the administration of tonics; vaccination with tuberculin may prove of some value. Possibly, if the disease is not too extensive, benefit may be derived from scraping away the tuberculous tissue through a perineal incision.

Prostatic Calculi are of unfrequent occurrence, being usually met with in cases of chronic prostatitis, especially that resulting from stricture of the urethra or previous attacks of gonorrhœa. They are generally multiple, and of small size, consisting mainly of carbonate of lime. They develop primarily in the glandular crypts, and may remain embedded in the organ, giving rise to but little inconvenience. When large and protruding from the gland into the urethra, symptoms of obstruction to the flow of urine are produced whilst on passing a catheter or sound a distinct click or grating may be noticed. In the latter case, great irritability of the neck of the bladder is induced. Sometimes a number of them are found in a pouch or pocket, formed by the amalgamation of several of the crypts. Diagnosis can be effected in some instances by radiography, the calculi casting shadows usually a little below the brim of the pelvis. It is in some instances possible to remove the calculi through the urethra, but more frequently a perineal incision is required.

Enlargement of the Prostate (or, as it used to be termed, *senile hypertrophy*) is a condition rarely seen under fifty years of age, characterized by a chronic persistent overgrowth of the organ, which results in interference with the act of micturition, and may finally destroy life by inducing secondary changes in the bladder and kidneys by prolonged backward pressure. As to causation, but little is known; it is not apparently attributable to excessive sexual indulgence. It may attain a considerable size, perhaps constituting a tumour as large as one's fist and weighing 200 grammes, the average normal weight of the prostate being about 18 grammes. It may be of hard or soft consistence, and in the latter case is extremely vascular. The vascularity varies from time to time, and the patient is liable to sudden attacks of congestion, which aggravate the symptoms. On section the organ may appear to be homogeneous and of the same texture throughout, but most commonly it consists of a number of firm rounded masses, sharply defined, and held together by a certain amount of connective tissue. Outside these is an ill-defined layer of stretched (and sometimes atrophied) muscular tissue, containing a few glandular elements, but continuous with the stroma, and constituting the true capsule of the organ. Still further out is the extrinsic sheath, derived from the pelvic fascia (mainly recto-vesical); it consists of two layers, between which are the veins of the prostatic plexus.

Histologically, an enlarged prostate consists of an overgrowth of the glandular tissue, sometimes diffuse, more frequently in the form of multiple adenomata, set in a connective-tissue basis developed from the prostatic stroma of muscle fibres. Cystic changes are not unusually observed in these adenomata. Occasionally a few fibromyomata may develop, but they are decidedly uncommon.

The changes induced in connection with an enlarged prostate are numerous and important.*

1. The prostatic sheath of pelvic fascia becomes thickened and condensed, thereby preventing any downward expansion of the organ, and directing its enlargement upwards.

2. The close connection between the capsule and the sheath, which is so marked a feature in the normal anatomy of the organ, is profoundly modified, so that it becomes easy to enucleate the gland in its entirety from its surroundings.

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* *Vide* 'The Surgical Anatomy of the Normal and Enlarged Prostate,' by J. W. Thompson Walker, *Med.-Chir. Trans.*, vol. lxxxvii.

3. The relations to the bladder wall are also much altered. Normally, the sphincter (Fig. 553, S.V.) is interposed between the prostate and the vesical mucosa. As the gland enlarges, this relation may persist (Fig. 554), and although the bladder base is raised up, the growth is extravesical, and the sphincter muscle covers over the enlargement. More frequently, however, the gland, as it enlarges, insinuates itself between the sphincter and internal meatus, constituting an intravesical enlargement (Fig. 555). This is generally most marked in the middle line behind, constituting the so-called 'middle lobe'* (Fig. 556); but it may involve the whole gland, which projects into the bladder as a collar-like enlargement around the meatus, whilst sometimes one or both of the lateral lobes are chiefly affected in this manner. The gland also pushes backwards between the seminal vesicles, which in time are displaced from their connection with the back of the bladder, and constitute a posterior relation with the enlarged organ. It is interesting to note that this overgrowth involves mainly, if not entirely, the upper part of the gland, and that the portion below the verumontanum is rarely affected, so that the openings of the ejaculatory ducts are not displaced backwards.

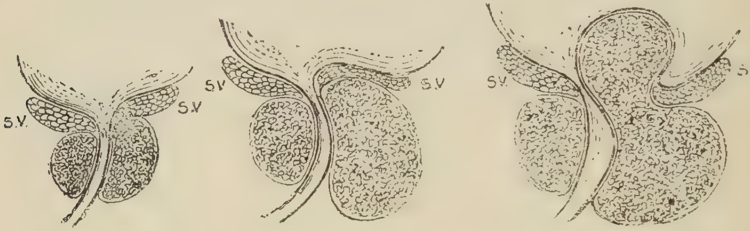

FIG. 553 FIG. 554. FIG. 555.

FIGS. 553-555.—DIAGRAMS TO ILLUSTRATE RELATION OF THE PROSTATE TO THE SPHINCTER VESICÆ (S.V.).

In Fig. 553 the prostate is supposed to be of normal size, and the sphincter lies above it; in Fig. 554 the prostate is enlarged, but has no intravesical projection or 'middle lobe,' and hence the sphincter retains its normal relation; in Fig. 555, the most common type of prostatic enlargement, a well-marked intravesical projection or middle lobe exists, the sphincter being displaced backwards by this development.

4. The changes produced in the prostatic urethra and neck of the bladder vary considerably in different cases. The length of the urethra is always increased, perhaps by 2 or 3 inches, or even more. Some amount of obstruction to the outflow of urine is universal. In rare instances it may be due to an adenoma becoming pedunculated, and projecting downwards into the urethra as a polypus. Occasionally the base of the middle lobe becomes narrowed, probably as the result of constriction by a band of longitudinal muscle fibres

* Students must remember that in the normal prostate there is no middle lobe, and that the structure thus named is caused by an abnormal overgrowth or projection from one of the lateral lobes.

passing down on either side from the ureteral orifice to the meatus; the middle lobe thereby becomes more or less pedunculated, and may be moveable, constituting a ball-valve which determines retention, or else wedging open the internal meatus and causing incontinence. As a rule the outflow of urine is hindered by the 'prostatic bar,' caused by the projection of the middle lobe, which also hinders the entrance of a catheter. When both lateral lobes are enlarged symmetrically, the lumen of the urethra is diminished from side to side, being narrow or chink-like instead of triangular, but its vertical measurements are increased. Asymmetrical enlargement, of course, displaces the urethra to one or other side.

5. The *effect* of an enlarged prostate *on the bladder* is important. The obstruction to the outflow of urine leads to increased expulsive efforts on its part, and consequently the wall becomes thickened and hypertrophied. This involves the muscular fibres, which stand out prominently as rounded fasciculi, and the mucous membrane may project outwards between them as hernial protrusions, constituting saccules in which urine may stagnate and decompose, and even phosphatic concretions form.

In almost every case the enlarged prostate projects more or less into the vesical cavity, either as a collar-like mass around the internal meatus, or as one or more rounded outgrowths. This is necessarily associated with a pouching backwards of the lowest part of the bladder (*prostatic pouch*), which, being below the level of the meatus, does not become emptied during the natural process of micturition, and in which *residual urine* is therefore able to collect and remain.

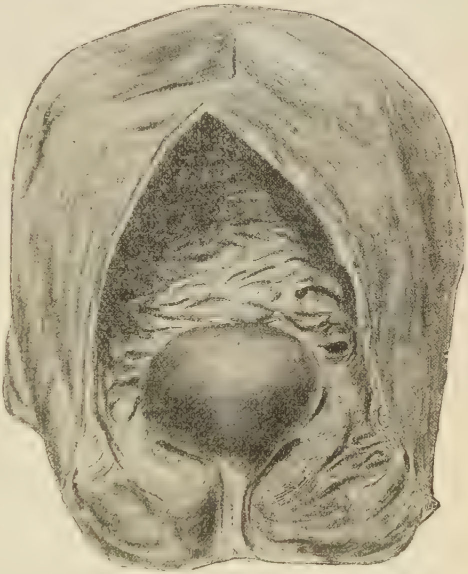

FIG. 556.—ENLARGED PROSTATE WITH A LARGE INTRAVESICAL PORTION. (FROM COLLEGE OF SURGEONS' MUSEUM.)

Cystitis is very likely to follow, either by infection from within or from the use of unsterilized instruments, and then the bladder wall becomes inflamed; ammoniacal decomposition of the urine follows, and renal complications may ensue (either hydronephrosis or pyonephrosis), which will determine a fatal issue.

The **Symptoms** vary somewhat with the nature and position of the enlargement. The patient at first finds some difficulty in micturition, especially at the commencement of the act; straining often hinders rather than assists. The stream is not necessarily smaller than formerly, but is projected with less force. Gradually irritability of the bladder ensues, and the patient has to pass water very frequently, a trouble especially noticed during the night. Some degree of pain and a sense of weight and fulness about the perineum are also experienced, whilst tenesmus, and even hernia, may be subsequently induced by the straining. Intermittent attacks of increased pain and difficulty in micturition occur from time to time, being generally induced by exposure to cold and wet, and presumably due to congestion of the prostate. After lasting for a few days the more acute symptoms slowly disappear, if judiciously treated.

As the obstruction increases, a certain amount of residual urine remains within the bladder after each act of micturition, the vesical muscles in time losing power and becoming atonic. Well-marked distension and atony of the bladder ensue at length in neglected cases, the urine dribbling away and wetting the clothes, whilst decomposition of the retained fluid follows, and causes cystitis with increasing vesical irritation and muscular spasm. The urine becomes alkaline after a time, containing muco-pus and phosphates, the result of chronic cystitis. This, if untreated, is certain to lead to hydronephrosis and pyelonephritis. The general health of the patient is slowly undermined by the constant irritation produced by this process, as also by toxic absorption, and the final chapter may be ushered in by symptoms of uræmia from the mischief inflicted on the kidneys.

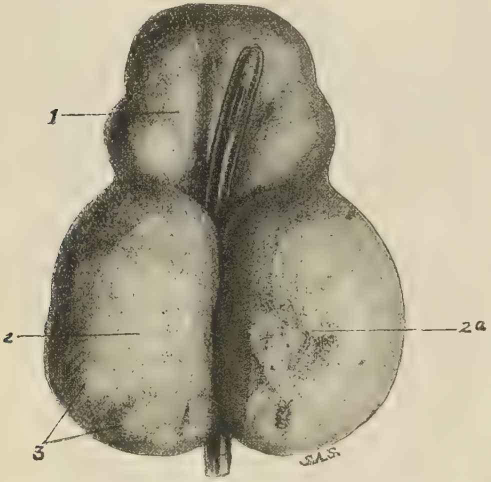

FIG. 557.—ENLARGED PROSTATE AFTER REMOVAL BY SUPRAPUBIC OPERATION.

The catheter has been placed in the urethra. 1, The so-called middle lobe, or intravesical projection behind the internal meatus; 2 and 2*a*, the lateral lobes; 3, indicates the nodular adenomatous masses which constitute the bulk of the swelling.

Occasionally the early symptoms may pass unnoticed for a considerable time, the patient imagining that the frequent calls to pass water are good signs rather than evidences of disease. In such cases the bladder may become over-distended, and the condition unsuspected until, owing possibly to some exposure to cold or over-indulgence in alcohol, complete retention is induced, and then, to the surprise of the patient, an enormous amount of urine is withdrawn on the passage of a catheter. Priapism is sometimes a troublesome condition, and the effect of this on the moral sense may be very serious, and leads in some cases to acts of gross indecency.

The **Diagnosis** of enlarged prostate is made partly by a consideration of the symptoms complained of, but mainly by an examination of the urethra and rectum. The age of the patient, the increasing irritability of the bladder by night and day, the fact that straining hinders rather than helps the expulsive act, together with evidence of vesical distension—all these facts indicate that the seat of obstruction lies in the prostate. A rectal examination is then instituted, and some idea gained of the size and condition of the organ; it must not be forgotten, however, that the size, as recognised by a finger in the rectum, cannot measure in any way the amount of obstruction to the passage of the urine, and, in fact, it often happens that where the gland does not feel especially large from the rectum, the obstruction is the greatest. The careful introduction of a catheter will assist in making the diagnosis, inasmuch as the barrier at the neck of the bladder is easily detected, and sometimes with difficulty passed. For the diagnosis from cancer of the prostate, see p. 1252.

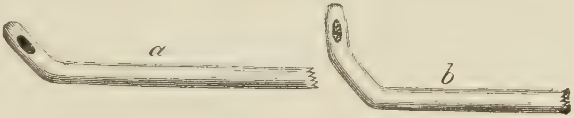

FIG. 558.—CATHETER COUDÉ AND BICOUDÉ.

Treatment.—All that is required at first is regular catheterism, in order to prevent the bladder from becoming over-distended, and this the patient may often be taught to do for himself. To pass a catheter in a case of enlarged prostate is not always easy, owing to the fact that the middle lobe (Fig. 555) projects across the urethra, and bars the onward progress of an instrument of the ordinary shape. The surgeon should therefore use a catheter coudé or bicoudé (Fig. 558), which consists of a soft, straight instrument of the usual French type, the end of which is bent or doubly bent at an angle, like an elbow, so as to enable it to ride over the obstruction; or he may employ an English gum-elastic catheter, the stilette of which is drawn out a little so as to increase its curve; or he may utilize the silver prostatic catheter, which is longer and more curved than usual, depressing it well between the thighs after clearing the pubic arch. Whichever method is adopted, no force is required since with a little skill the point of the instrument will pass round the obstruction and enter the bladder. Every precaution must be taken to ensure the efficient sterilization of all instruments employed, and it should be remembered that as a general rule large rather than small instruments will pass more easily.

During the first fortnight of catheter life the patient must be carefully guarded from cold and exposure, to avoid the occurrence of constitutional disturbance. Not unfrequently a certain amount of fever (to which the name of **Catheter Fever** was given by the late Sir Andrew Clark) is produced, which either passes off in the course of a few days, or may increase, together with symptoms of chronic cystitis, running on to a fatal issue at the end of three or four weeks. The origin of this condition is still somewhat doubtful; it probably arises from the absorption of micro-organisms or their products from the urethra, or from the use of dirty instruments, but possibly reflex nervous disturbance plays some part in its production. The only treatment required in the simpler cases is to keep the patient warm in bed, to limit his diet, to administer quinine and perhaps opium, and to keep the bowels well open.

During the continuance of catheter life, the patient must be warned to live quietly, and abstain from all excesses, especially as regards eating and drinking; sexual excitement should be avoided, and horse-exercise forbidden; precautions must also be taken to ensure protection from cold and damp. The administration of alkalies is desirable if the urine is highly acid, so as to diminish the irritability of the bladder.

Under such a régime, it is possible that the patient may live in comparative comfort perhaps for years, the progress of the affection being entirely checked in some instances. In others, the patient suffers from intermittent attacks of congestion of the prostate, with increased pain and irritability of the bladder, and augmented difficulty in micturition. The introduction of a catheter is then very likely to cause bleeding, but a few days' rest in bed, hot baths and the administration of ergot, usually bring about considerable improvement. If there is much difficulty in passing a catheter, it may be wise to tie it in for a time, or even suprapubic aspiration may be required. The progress of the case depends, to a large extent, upon the bladder remaining free from septic contamination, and the surgeon must realize and impress upon his patient that such is generally due to infection from without, and hence the most scrupulous care must be taken to sterilize all instruments before and after use. In cases where the relief given by regular catheterism is but temporary, and the irritability of the bladder or the amount of residual urine increases seriously, or the patient wishes to be freed from the wearisome necessity of regular and perhaps frequent catheterism, operation for removal of the enlarged organ may be recommended.

Prostatectomy was originally practised by McGill of Leeds many years ago, but it has only been established as a successful and eminently practicable procedure for a few years, and that mainly by the energy of Mr. P. J. Freyer. There has been much discussion as to whether the whole prostate is removed from its fascial sheath in this precedure, or merely an intraglandular enucleation performed.

This probably depends largely on the technique; either procedure is possible, and in the more exaggerated cases there is not much to choose between the two, as the enlarged organ is entirely adenomatous, and the intrinsic capsule is thinned and atrophic. The surgeon's aim, however, should be directed towards the complete removal of the organ, the line of cleavage being placed between what we have described as the capsule and the fascial sheath. Two methods of approach are possible—viz., from the perineum or by the suprapubic route. Personally, we are at one with the majority of surgeons in preferring the latter.

Suprapubic Prostatectomy.—If there is much cystitis, the bladder must be carefully prepared for a few days by keeping the patient in bed and washing it out with a mild antiseptic, or even possibly by draining it. At the time of operation it is again irrigated, and some 6 ounces or so of boric acid lotion left in it. The patient is placed in the Trendelenburg position, and the usual suprapubic incision made into the bladder. The vesical wall is by some anchored to the abdominal parietes by a deep silkworm gut stitch on either side, so that it shall not be unduly torn or displaced in the subsequent manipulations; this step is not essential, although the introduction of a silk sling through the bladder wall on either side is desirable. The portion of the prostate projecting into the bladder is now carefully examined and its removal commenced. The index and middle fingers of the left hand (which is covered with a sterilized india-rubber glove) are introduced into the rectum so as to steady and push forwards the prostate. The right index-finger tears through the mucous membrane behind the projecting median lobe or collar, thus passing between it and the displaced sphincter vesicæ. It will often be found an easy matter to pass the finger round the enlarged organ and enucleate it; the larger the prostate, the more easily this is effected; but when it is comparatively small and hard, enucleation may be difficult. In this procedure the ejaculatory ducts are torn across, as also the vessels which enter and leave the gland on either side. The urethra is either removed entirely, or the lower portion of it is detached and left behind. The prostate when free in its sheath remains either in one mass, or not unfrequently separates into two halves, which can be peeled off the urethra and removed separately from the bladder.

This enucleation is attended by remarkably little bleeding in the majority of cases, and even when at all free it can be quickly restrained by irrigating the cavity and bladder with hot saline or boric acid solution through a catheter. A large rubber tube is passed into the bladder and stitched in the lower angle of the wound, the upper end of which is closed by deep sutures. The wound is covered with a few layers of cyanide gauze, and over this absorbent wool is placed in sufficient quantity to take up the urine secreted. Morphia is often needed to combat the pain and spasm that supervene, and it is advisably given as a suppository, or as a starch and laudanum enema. The subsequent treatment varies somewhat. Probably the best method is to dress the wound with gauze and wool, which are renewed every four or six hours as may be required. The amount of dressing required is large, and the expense is considerable. Some surgeons employ Irving's apparatus, a glass cap which fits closely over the wound, kept in place by elastic bands round the body, and draining into tubes which carry away the urine to a bottle between the legs. This appliance keeps the patient dry, and saves the expense of dressing; but it keeps the patient on his back, it presses on the wound and lower abdomen, and probably it hinders the healing process somewhat. The bladder is irrigated daily through the suprapubic incision, and blood and small sloughs will escape for some days. As soon as the suprapubic wound is protected by a layer of granulations, the tube should be withdrawn, and the urine allowed to escape or to collect in the bladder. A catheter is passed about the end of the first week, and the bladder washed out through it. The patient is allowed up in an arm-chair as soon as possible to avoid pulmonary complications. Not unfrequently he will commence to pass urine naturally in about a fortnight or three weeks, and subsequently the function will be maintained in a normal fashion.

In **Perineal Prostatectomy** a median staff is passed, and then the membranous urethra and apex of the prostate are exposed, either by an antero-posterior or transverse incision in the perineum. The fascial sheath of the prostate is torn through or divided by the knife, and enucleation is then carried out by the finger, assistance being derived by pressing the bladder downwards from above the pubes. It is claimed that the urethra is less damaged in this procedure, but its advantages are not apparent.

If the patient refuses operation, or if his general condition prevents it from being undertaken with safety, and catheterism is insufficient to give relief to his symptoms, a *permanent fistula* either above the pubes or through the perineum must be established, necessitating the use of a portable urinal. This is effected by introducing a trocar and cannula into the bladder, and leaving it there until a sufficient track has been formed.

Cancer of the Prostate occurs in elderly men, but is more common than was formerly supposed; it is usually of a scirrhous type, though sometimes it is of a soft nature; in either form it early progresses beyond the limits of the capsule. The symptoms produced are at first similar to those caused by simple enlargement of the prostate; but the progress of the case is much more rapid, the amount of pain and discomfort is much greater, and the pain is often referred to the back of the thighs and down the legs. Later on hæmaturia may occur. On rectal examination a hard mass is readily detected, fixed more or less to surrounding parts, and perhaps with outlying nodules distinct from the main mass; secondary deposits may be found in the lumbar and abdominal glands on palpating the abdomen. Occasionally phenomena referable to pressure on the abdominal vessels and nerves arise, and the symptoms of general cachexia soon manifest themselves. Palliative treatment alone can be adopted in the majority of cases.

CHAPTER XLI.

AFFECTIONS OF THE URETHRA AND PENIS.

Affections of the Urethra.

Congenital Malformations.—**Total Absence,** or **Occlusion,** of the urethra has been met with, the urine under such circumstances being sometimes retained, and leading to dilatation of the bladder, ureters, and kidneys, a condition rapidly fatal, even if the child be born alive. In a few cases the urachus remains patent, and a congenital urinary fistula is established at the umbilicus, whilst in others the cloacal condition persists, the rectum communicating with the bladder (Fig. 526).

Epispadias is a deformity in which the urethra is partially or wholly exposed along the upper surface of the penis. According to Sir Henry Morris, it is not, properly speaking, a division or deficiency in the upper wall of the urethra, but in its floor, which has been transposed to the dorsum by torsion of the penis. 'It is thus, in fact, a hypospadias reversed—*i.e.*, upside down.' In rare instances the external meatus is situated just above the glans, which is cleft and deeply grooved superiorly. More commonly the urethra opens at the root of the penis, just in front of the symphysis, and in such patients the organ is always rudimentary and stunted. Complete epispadias is only present when associated with extroversion of the bladder (p. 1216). The incomplete form has been treated with success by the use of reversed flaps dissected up from the side of the penis. For details of the operations on this and the following conditions, see larger text-books on operative surgery.

Hypospadias, or defective development of the lower wall of the urethra, is a much more common malformation than the foregoing. Three varieties are described. In (*a*) *hypospadia glandis* the opening of the urethra corresponds to the position usually occupied by the frænum, and is thus directed downwards instead of forwards. The prepuce in these cases is always voluminous, and hangs like a hood over the glans, which is bent down over the orifice. (*b*) *Hypospadia penis* is characterized by the urethra opening somewhere along the under surface of the body of the penis, which is often small and stunted. Considerable discomfort may arise in the act of micturition, owing to the urethral orifice looking downwards; it is also sometimes so small as to require incision and dilatation. (*c*) Complete hypospadias, or *hypospadia perinealis*, is a somewhat complicated condition, in which the lower wall of the urethra is defective as far back as the perineum, the scrotum being cleft, and thus resembling the vulva. The penis is always small, imperfectly developed, and bound down by adhesions between the scrotal segments, looking not unlike a hypertrophied clitoris, and late descent of the testes is common. Under such circumstances it is not surprising that the sex of the child has been mistaken, and not a few cases are on record where it has been educated as a female until the age of eighteen or twenty.

In the incomplete varieties, where the deformity is slight and the urethral opening well in front of the scrotum, no interference is necessary; but where it encroaches on the scrotum, causing inconvenience and discomfort, and threatening to prevent effective sexual intercourse in the future, the restoration of the urethra may be attempted by the use of flaps obtained from either side, or from the redundant prepuce. In the complete form the penis must first be liberated from its adhesions and set free; the integument lining the scrotal cleft is then dissected up and turned inwards to form the posterior part of the urethra, whilst the lateral halves of the scrotum are brought together with sutures; the anterior portion of the urethra may then be dealt with as for the incomplete variety.

Traumatic Laceration of the Urethra usually results from violence applied directly to the perineum, as by falling astride a stile, fence, or beam; it has also been caused by severe jolting in the saddle, or by a kick in the perineum. In fractures of the pelvis it may be produced by a spicule of bone puncturing the canal, and the membranous portion is that generally affected. The whole circumference of the urethra may be involved, the two segments being entirely disconnected, or only a portion may be ruptured, and that most frequently the floor.

The **Symptoms** consist of pain in the perineum and shock, followed by great distension of the scrotum from hæmorrhage, whilst blood trickles from the urethral orifice. If the patient is able to restrain himself from passing water, and is successfully treated, no extravasation of urine results, since the lesion is below the sphincter vesicæ; if, however, he attempts to micturate, the urine finds its way into the perineal and scrotal tissues. Whether the rupture is complete or not, an organic stricture of considerable density is almost certain to follow, and great difficulty is subsequently experienced in keeping it dilated.

Treatment.—In the slighter cases, where it is probable that the mucous membrane has alone been torn, and there is no perineal swelling, the patient should be kept quiet in bed, and no attempts made at instrumentation. If urinary infection of the wound occurs, and an abscess forms, it can be dealt with by incision at a later date.

Where, however, it is thought that the urethra is partially or wholly divided, no temporizing measures, such as tying in a catheter, even if that be possible, should be adopted. An incision ought to be made at once into the perineum so as to expose the divided ends of the urethra, which it is the surgeon's aim to unite. The blood-clot is removed, bleeding points are secured, and if the ends of the urethra can be identified, a soft catheter is introduced into the bladder, and they are sutured together around it with fine catgut. When the ends are much torn, it is wise to cut away the bruised extremities so as to have clean, smooth surfaces to deal with. Under any circumstances, the catheter must be kept in for five or six days, if possible, and subsequently an instrument should be passed every day for some time.

If a catheter cannot be introduced, or if extravasation has occurred, free incisions must be made into the scrotum and perineum to give exit to the blood and urine, and to expose the seat of injury. A catheter is passed as far as possible, and its point felt for, cut down on, and guided into the bladder; a prolonged attempt under anæsthesia may be necessary to accomplish this, and even then it is useless to attempt to stitch up the urethra, as the sutures are certain to cut out. Occasionally, and especially if treatment has been delayed, the swelling of the parts is so great as to render the passage of a catheter impossible. The patient must then be put to bed for a few days until the blood-clot has disappeared, the urine in the meantime escaping through the perineal wound; but as soon as possible another attempt must be made. When once the catheter is passed, it must be retained for several days, so as to establish the continuity of the tube.

Foreign Bodies are sometimes found in the urethra, usually consisting of a portion of a catheter, pipe-stem, or in children a piece of slate-pencil. Their presence gives rise to partial or complete obstruction to the flow of urine, followed by ulceration of the mucous membrane, the formation of a peri-urethral abscess, or even extravasation. They are readily detected on the passage of a sound or catheter, and may be removed by suitable forceps if situated near the orifice. Should this fail, the urethra may be incised and the body extracted; a troublesome urinary fistula is apt to follow this proceeding, even when the wound in the urethra has been carefully sutured.

A pin is sometimes introduced voluntarily into the urethra, and is not easily removed, since it has usually been pushed in head-foremost. The following manœuvre is necessary in order to remove it: The point is made to penetrate the floor of the urethra and skin by a sharp push on the head from behind. The body is pulled out until the head catches against the mucous membrane, and then the direction of the pin can be changed, so that the head presents at or towards the meatus.

Impacted Calculus is a not unfrequent cause of retention in children. It can usually be felt through the walls of the canal.

The symptoms and treatment are much the same as for foreign bodies. When near the neck of the bladder, it should be pushed back into that viscus, if possible, and treated by lithotrity.

Simple Urethritis may arise from a variety of causes apart from gonorrhœa—*e.g.*, the presence in the female of an irritating vaginal discharge, such as leucorrhœa, and possibly due to the *B. coli.* It also occurs after the passage of an instrument or of a calculus, and is occasionally excited in gouty individuals by highly acid urine, charged presumably with spiculated crystals of uric acid. The symptoms are much the same as those of gonorrhœa, but the discharge is thinner in character, and on microscopical examination no gonococci are detected. The treatment consists in the administration of alkalies and saline purgatives, all forms of alcohol being interdicted. In more severe cases oleo-balsams may be prescribed, and even mild injections.

Polypoid Tumours, similar in character to the caruncle met with in the urethra of women, have been observed at the orifice of the male urethra. They are red, vascular, and sometimes exceedingly painful, and are best dealt with by excision, followed by the application of the galvano-cautery, so as to stop the bleeding, which is always copious. If of large size, the base may be ligatured and the growth cut away.

Epithelioma of the urethra is usually secondary to some other malignant development in the neighbourhood—*e.g.*, of the prostate. Occasionally, however, it is primary, and then frequently the sequela of an old stricture. It constitutes a hard swelling of the urethra, which infiltrates surrounding parts, and there is usually some discharge of blood and pus from the meatus. Micturition is consistently painful, and the introduction of an instrument increases both the pain and bleeding; it generally passes easily, but the irregularity of the surface of the growth can be recognised. Examination by the urethroscope (p. 144) is desirable in such cases. Amputation of the whole penis is usually required.

Stricture of the Urethra.—By stricture of the urethra is meant a condition in which the onward passage of urine is hindered, owing to some change in the walls of the urethra, which prevents them from dilating. When at rest, the urethra is merely a potential canal, the walls of which are in complete apposition, and it is only converted into a tube when urine is passing along it. When, owing to some change in the structure of its walls, this functional dilatation is impracticable, the patient is said to suffer from stricture. Three forms of stricture are described—viz., the spasmodic, congestive, and organic.

Spasmodic and Congestive Strictures frequently co-exist, although either congestion or spasm may be the predominant feature in any particular case. Thus, in acute gonorrhœa the mucous membrane often becomes engorged and thickened to such an extent as to interfere with the act of micturition. Spasm is the chief element under the following conditions: (1) When a patient, suffering from slight organic stricture, is exposed to wet or cold, especially after heavy drinking; (2) as a result of catheterism; and (3) from perineal irritation of the urethra, as by a blow or kick in this region, or from prolonged riding on a bicycle with a badly-fitting saddle or on horseback. Temporary retention is the usual result of any of these conditions, and, as a rule, no *treatment* is required beyond placing the patient in a hot bath, and unloading the lower bowel by the use of a large warm enema. If such fails, catheterism will be necessary, and must be conducted with the greatest gentleness, owing to the congested and lacerable condition of the mucous membrane. Full-sized soft instruments should first be used, and will usually succeed; if not, a silver instrument must be substituted.

Organic Stricture is the term applied to an undilatable condition of the urethra, resulting from the development of cicatricial tissue within its walls.

The **Causes** of organic stricture are: (*a*) The long continuance of a urethral discharge, following gonorrhœa, or the frequent recurrence of this affection. Chronic inflammations are always characterized by a tendency to sclerosis of the tissues involved, and the urethra is no exception to this rule, its walls under these circumstances becoming thickened, indurated, and contracted. (*b*) The cicatrization of a urethral chancre, or of an ulcer caused by the impaction of a stone, or the contraction produced by the healing of a urethral abscess, may also lead to stenosis. (*c*) The most intractable forms of stricture are those due to cicatrization after rupture or laceration of the urethral wall.

The usual **Situation** is within the bulb—*i.e.*, just in front of the triangular ligament; but the orifice and body are not unfrequently affected. It occurs in the membranous portion only as a result of traumatism, and never in the prostatic. To find more than two strictures in any particular case is unusual, although three or four have been met with.

Various terms are applied to a stricture according to the physical conditions present; thus, it is termed *annular*, if it involves the whole lumen of the urethra; *bridled*, if it affects only a portion of the circumference of the tube. A *ribbon-shaped* stricture is one in which a considerable extent of the wall is contracted (*i.e.*, as if a ribbon had been tied around the urethra). It is termed *tortuous*, if the resulting passage is not straight; *indurated*, if the walls are very hard and thickened; and *resilient*, when the stricture, though readily dilated, rapidly re-contracts. The terms *impassable* and *impermeable* are applied to strictures through which, on the one hand, a surgeon is unable to pass an instrument, or along which, on the other hand, urine cannot find its way; it is doubtful whether the latter condition ever occurs, whilst the number of impassable strictures met with by the surgeon diminishes with his experience and ability in passing instruments.

The **Symptoms** of urethral stricture vary according to the case. The patient generally complains of difficulty in the act of micturition, the stream becoming small, and perhaps forked or twisted. It takes a longer time than usual to empty the bladder, and even when apparently successful a few drops of urine may trickle away, wetting the patient's clothes. Irritability of the viscus follows, leading to frequent attempts to pass water at short intervals during the day and night. The urine under these circumstances often becomes alkaline, and loaded with muco-pus and phosphates. As the obstruction increases, more and more residual urine is left in the bladder, which may in time form a tense, rounded, dull swelling in the hypogastrium. The quantity of urine trickling away also increases, so that the patient's garments are always wet, giving him an unpleasant urinous odour. A certain amount of gleety discharge is present, whilst if the individual takes an excess of alcohol, or is exposed to wet and cold, complete retention may ensue. Sometimes the onset of symptoms is so insidious that such an attack of retention is the first marked feature in the case.

The **Pathological Conditions** arising from a stricture are best considered under the following five headings: (1) The *urethra anterior* to the stricture is usually in a perfectly normal state, although possibly the orifices of false passages may be seen. A few granulations are sometimes present, projecting at the commencement of the stricture. (2) The *stricture itself* is characterized by the development of fibro-cicatricial tissue immediately under the mucous membrane, and intimately adherent to it. It extends for a variable distance, and is often associated with a good deal of peri-urethral infiltration. (3) The *urethra behind the stricture* is dilated, and the mucous membrane velvety and friable; the orifices of the lacunæ and other glands are somewhat enlarged and more than usually evident, and perhaps ulceration may be present around them. In the later stages the inflammation may extend to the peri-urethral tissue owing to lymphatic absorption, or perhaps to the escape of a few drops of urine; a perineal abscess then results, leading subsequently to perineal fistulæ. When the obstruction becomes almost absolute, this portion of the urethra may give way, leading to extravasation of urine into the perineum and scrotum. (4) The *bladder* invariably manifests considerable changes in structure. At first the vesical wall undergoes a compensatory hypertrophy of its muscular elements and is thickened, in order to overcome the obstruction to the onward passage of urine (Fig. 559). The lattice-work arrangement of the muscular bands becomes coarse, thickened, and evident, causing the vesical wall to assume a fasciculated appearance. As the pressure increases, the mucous membrane protrudes between the muscular fasciculi, giving rise to sacculation; it is also thickened and congested as a result of chronic cystitis; the superficial veins become varicose, and hæmaturia may be caused by their rupture, whilst ulceration may also occur. The urine becomes alkaline and decomposes, containing muco-pus and phosphates. It is likely to stagnate in any sacculi which exist, and may then determine the formation of phosphatic concretions; or the walls of the sacculi ulcerate, and after a time perforation and extravasation of urine into the cellular tissue lead to a fatal issue. Occasionally the bladder, instead of being thickened, is dilated and atonic, with very thin walls. (5) Consequent on the changes in the bladder, the conditions already described as hydronephrosis, pyonephrosis, or pyelonephritis may develop, partly as the result of the backward pressure, and partly from the extension of septic matter along the ureter to the pelvis of the kidney and calyces.

Physical Examination.—The actual diagnosis of a stricture can only be confirmed by a careful physical examination of the urethra, which is usually made by the introduction of a full-sized catheter or a solid bougie —*e.g.*, No. 9 or 10 (English)— so as to ascertain where the obstruction is situated. If this cannot be passed, smaller instruments, and even filiform bougies, are inserted until one is found which will enter the bladder.

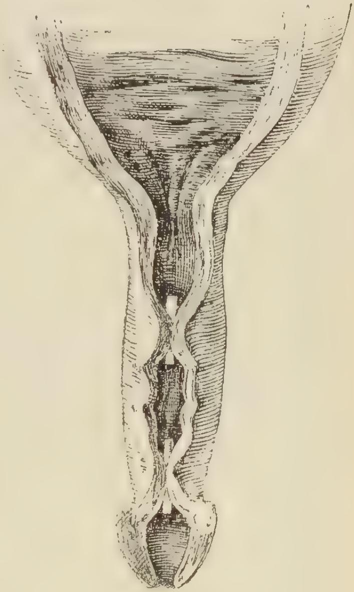

FIG. 559.—DOUBLE STRICTURE OF THE URETHRA. (COLLEGE OF SURGEONS' MUSEUM.)

Glass rods have been passed under the strictures. The bladder is somewhat dilated, and its walls are thick and hypertrophic, and with commencing sacculation.

A great variety of *catheters* is in use; in old days only metal instruments were obtainable, and even now the silver catheter is the favourite with many surgeons of eminence. In selecting such an instrument, care must be taken that it is suitably curved, and that the 'eye' is sufficiently large and bevelled inwards, so that no projecting rim lacerates the urethral mucous membrane. The great advantages of the metal instrument are that it is easily kept aseptic, and that the point can be located and thus guided more readily along the urethra. Of late years many different forms of flexible catheters have been introduced, and are now extensively employed, inasmuch as they give rise to less irritation than those made of metal. The objections to them are that the materials of which they consist are readily attacked and injured by antiseptics, whilst they are less easily directed through a stricture on account of their flexibility, it being impossible to know with certainty the situation of the point. Probably the best means of sterilizing a soft instrument is to expose it to the action of steam, which should be made to act not only on the exterior, but also inside the tube; many appliances to obtain this object have been devised. Failing this, they may be syringed through with 1 in 20 carbolic lotion and allowed to soak for a while in a 1 in 2,000 sublimate solution; or they may be kept aseptic by hanging or lying in an atmosphere charged with formalin vapour, by placing a few tabloids charged with this substance in the bottom of a jar in which they are suspended. Amongst the best flexible instruments are the indiarubber or Jacques' catheter (the distal end of which beyond the eye should be solid and not hollow), the English or gum-elastic catheter, the French olive-headed or catheter-à-boule, and others made of silk-web coated with shellac, etc. Some varieties are now polished and prepared inside as well as out, and these should, if possible, always be selected.

Bougies or solid instruments are preferred by some surgeons for the examination and treatment of strictures. Those known as Lister's bougies are the best, consisting of solid metal rods, curved like catheters, the bulbous ends of which are three sizes smaller than the shanks, thus enabling each instrument passed to prepare the way for the next. Flexible bougies are also made, whilst for finding a way through a tight and tortuous stricture a filiform bougie, made of whalebone or catgut, or a long graduated whip-lash bougie may be employed; in the latter variety, the fine end is passed through the stricture, and coils up in the bladder, whilst the thicker portion is thus brought to bear on the stricture.

In order *to introduce a silver catheter or bougie*, the patient is laid on his back, the surgeon standing on his left side. The umbilicus should always be exposed, as also the upper parts of the thighs. The meatus and end of the penis are washed with a 1 in 2,000 solution of sublimate, as also the surgeon's hands. The catheter, which has been previously sterilized, warmed, and covered with sterilized or antiseptic oil or grease, is taken in the right hand, and inserted into the urethra, with the handle directed over the left thigh and slightly downwards. The point of the instrument is guided as far as the perineum, and then the handle is carried round to the middle line of the body towards the umbilicus; it is gently raised to the vertical, the penis being held in the left hand, and finally depressed between the patient's thighs, the so-called *tour-de-maître*. The catheter finds its way along the urethra into the bladder rather by its own weight than by any forcible action of the surgeon. The chief points at which difficulty may be experienced are: (*a*) The orifice, which may be small and contracted; (*b*) the lacuna magna, which is avoided by keeping the point of the instrument against the floor; and (*c*) the opening in the triangular ligament, which is best entered by keeping the point against the upper wall of the canal.

Some authorities recommend that the patient should stand up, with the back resting against a wall or firm support, the surgeon sitting in front, and manipulating, it is said, with greater accuracy. The objections to this position are: (*a*) The liability of the patient to faint, and (*b*) the existence of greater muscular tension than obtains in the horizontal posture.

When a flexible instrument without a stilette is used, it is passed by pressing the point on with a little rotatory movement until the bladder is reached, withdrawing a little, and pushing on again, if any obstruction is met. In some instances, however, the use of a stilette is absolutely necessary.

The chief **Dangers** of catheterism are as follows: 1. A considerable degree of *shock* is sometimes experienced, especially in sensitive individuals, and if an instrument has not been passed before. It may be obviated to a large extent by first introducing about ½ drachm of the 5 per cent. solution of cocaine into the urethra.

2. *Hæmorrhage* may be induced by laceration or abrasion of the mucous membrane, even though no false passage has been made; it is best avoided by gentleness and the use of well-finished instruments. In spite of these precautions, when the mucous membrane is soft and congested, and in many cases of stricture, some bleeding cannot be avoided. It is rarely sufficient to call for special treatment, but if very abundant may be arrested by the pressure of an instrument tied in or by injections of hazeline.

3. *False passages* are frequently produced in the treatment of strictures. The point of the instrument is most likely to leave the canal at some spot in the floor, travelling for a variable distance, according to the force employed, under the mucous membrane, occasionally re-entering the dilated urethra behind the stricture, which it avoids altogether, or perforating the posterior wall of the bladder by tunnelling under the prostate, an accident which can only occur in unskilful hands. The occurrence of a false passage is indicated by the sudden onward movement of the instrument, combined with pain and hæmorrhage; the point is usually deflected from the middle line, as is plainly seen by the obliquity of the rings at the end of the shaft; no urine comes unless the urinary passages are opened behind the stricture. On rectal examination, the instrument can be felt out of the middle line, and nearer the rectum than is normal, and in some exceptional cases has even been found in it. False passages are not necessarily matters of great importance, but when extensive may lead to peri-urethral suppuration and extravasation of urine. If the urine is very offensive, grave infective troubles may arise, even threatening life. Thus in one case seen recently the unfortunate patient suffered subsequently from gangrene of the penis, necessitating its almost complete removal, in spite of the fact that a free incision was made through the perineum into the urethra, and the urine was drained away.

4. Inflammatory phenomena may be lighted up in the prostate, and acute epididymitis induced by extension along the vas deferens; these are always due to infection.

5. **Urinary Fever,** or, as it is sometimes termed, urethral or catheter fever, is always liable to develop as a result of the introduction of instruments. It may occur as a solitary rigor even in

individuals with healthy urinary organs, but is much more frequently observed in those with damaged kidneys. As to its causation, there has been much discussion, but there can now be little doubt that it is essentially infective in origin. Possibly the instrument employed may be dirty, or the urethra itself contains infective material, especially in its deeper parts. It is quite sufficient for a slight abrasion to occur near the neck of the bladder, to allow of the absorption either of toxins or of bacteria, and then general phenomena show themselves at once. If merely toxic products are absorbed, probably a passing febrile condition, such as one or more rigors, will develop, with no more serious phenomena; but if bacteria find their way into the submucous tissues, they are likely to develop rapidly in the lymphatics, extending to the bladder and thence up the ureters owing to the continuity of lymphatic supply, giving rise finally to pyelonephritis (p. 1197). Formerly reflex congestion of the kidneys was thought to be an important factor in these cases; probably the congestion which occurs is due to the direct irritation of bacteria, and is not of nervous origin.

The *clinical manifestations* vary considerably, according to the character of the case and the type of infection. (*a*) The simplest form consists in the development of a single rigor, the temperature perhaps running up to 105° F.; the patient shivers and feels very ill, complaining of headache, but when the temperature falls he soon recovers, and within a few hours is all right again. (*b*) Sometimes the temperature does not fall to the normal after the initial rigor, but remains elevated a few degrees for a day or two, and there may even be a repetition of the rigor. The patient, however, recovers perfectly, and no permanent harm is done. (*c*) In the more serious cases the symptoms of pyelonephritis supervene, and are very likely to prove fatal, the patient perhaps dying in seven or eight days. (*d*) General pyæmia may appear as a complication of the last condition. (*e*) In patients who are commencing the regular passage of catheters for enlarged prostate a series of phenomena develop, which have been already alluded to (p. 1250), and though often mild, are of a similar nature. (*f*) Finally, suppression of urine may accompany any of the conditions alluded to above.

Treatment.—Whenever it seems probable that the kidneys are damaged, the greatest care must be taken in order to avoid infection. The instruments employed, whether bougies or catheters, must be thoroughly sterilized, and it would also be well to irrigate the urethra with a mild antiseptic lotion. It is better to use soft instruments, if possible, rather than silver ones, as the latter give rise to more irritation than the former, and are more likely to abrade the mucous membrane.

For the single rigor following catheterism, the patient must be kept warm, plenty of hot diluent drinks given, and quinine (2 grains) administered. If the febrile symptoms continue, the skin and bowels are freely acted on, and a milk diet prescribed, although a certain amount of stimulant may be given if necessary; all operative measures must be avoided, unless it is essential to relieve obstruction, as they are almost invariably fatal. Should suppression of urine ensue, the loins should be cupped in the hope of relieving renal congestion, a free action of the bowels obtained by the use of watery purgatives, and the patient made to sweat freely, either by the use of hot-air baths or by the injection of pilocarpine. If the urinary secretion is not quickly re-established (*i.e.*, in forty-eight hours), the surgeon should perform nephrostomy (*i.e.*, opening and draining the renal pelvis) without delay, selecting for operation the kidney which appears to be most tender; it may be necessary to incise both kidneys (p. 1199). Uræmic symptoms may sometimes be relieved by copious and repeated intravenous injections of saline solution, which encourage diuresis and a watery diarrhœa.

The **Treatment of Passable Strictures** is conducted either by dilatation or by a cutting operation (internal or external urethrotomy).

Treatment by **Dilatation** is effected in various ways, according to the nature of the stricture and the urgency of the symptoms. Where the obstruction is not serious, and an instrument can be easily passed, *gradual dilatation* should always be employed; this consists in the use of instruments once or twice a week, steadily increasing in size until a No. 12 is reached. If the intervals are too short, the urethra may become irritated, spasm be induced, and the lumen of the canal temporarily diminished in size; by keeping the patient quiet for a few days on a bland diet, and the bowels freely open, the spasm disappears. In cases where time is an object, *rapid dilatation* may be undertaken by the passage of several sizes of bougie at one sitting; for this purpose, Lister's instruments are particularly useful. Where only a very small catheter can be introduced, and that with difficulty, *continuous dilatation* may be adopted by keeping the patient in bed, and tying in the small instrument for forty-eight hours or more, at the expiration of which period a catheter several sizes larger can be substituted. This in turn may be tied in if the patient can bear it; but the presence of a catheter within the urethra for any length of time is not always tolerated, and may give rise at the end of two or three days to considerable constitutional disturbance and fever. *Forcible dilatation* is a plan which has now but few advocates. It consists in the passage of an instrument, the shaft of which is made in two portions, which can be separated from one another in such a way as to destroy the stricture either by distension or rupture of its substance. It is but little used, on account of the great tendency, when cicatrization is complete, to the formation of an even more intractable stricture than before.

By whichever of these methods dilatation is accomplished, it is essential that either the surgeon or the patient should subsequently pass an instrument through the stricture at first every week or two, and then at longer intervals, to overcome the tendency to re-contraction which is ever present.

The **Treatment of Passable Stricture** by a **Cutting Operation** is conducted either by excision or by internal or external urethrotomy.

Excision is certainly the ideal treatment, the urethra being thereby restored to a normal condition. It has now been frequently undertaken and with great success in strictures of the deeper perineal portion of the urethra; it is not so satisfactory when the penile urethra is involved. Fully an inch of the tube may be excised, and the ends sutured together over a catheter. The corpus spongiosum must be detached from its surroundings to permit of this. Sutures are introduced in the upper wall first; then the catheter is placed in position, and the remainder of the stitches inserted.

Internal Urethrotomy is a valuable means of treatment when rightly employed, but in careless or inexperienced hands may be attended with considerable danger. It has been performed either by passing an instrument through the stricture, and dividing it from behind forwards, or by passing an instrument down to the stricture, and dividing it from before backwards. The latter plan of treatment, though recommended by some skilled authorities, is not an operation which commends itself to our judgment, inasmuch as it is almost impossible to gauge the amount of tissue divided. The former plan of incising a stricture from behind forwards is, of course, only called for under special circumstances, since if the urethrotome can be passed through a stricture, ordinary dilatation is in the majority of cases practicable. It is useful, however, (*a*) in the treatment of very old and dense cartilaginous strictures, as also (*b*) for resilient strictures, and (*c*) when the urethra is excessively irritable. It should only be employed when the obstruction is situated in the anterior two-thirds of the urethra, and never when septic contamination of the urine is present. Many forms of urethrotome have been devised, but perhaps the most useful is that known as Civiale's (Fig. 560), which can only be used for a stricture which will admit the passage of a No. 5 catheter. The end is bulbous, and contains a hidden knife, worked by means of a button in the handle. The instrument is passed through the stricture, the cutting blade projected, and by withdrawing it the cicatricial tissue is notched to such an extent as to allow a full-sized catheter to be inserted at once, and, if possible, tied in. Where the deeper part of the urethra is being dealt with, the incision should be made along the roof so as to avoid the bulb. Care must be taken not to cut beyond the limits of the cicatricial tissue, otherwise hæmorrhage, peri-urethral suppuration, or even extravasation of urine, may ensue. It is also advisable to sterilize the urethra as far as

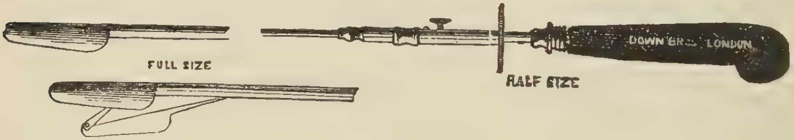

FIG. 560.—CIVIALE'S URETHROTOME. (DOWN BROTHERS.)

possible by washing it out with weak antiseptic solutions before operating.

External Urethrotomy, or **Syme's Operation**, is required under circumstances similar to those needing internal urethrotomy, if the stricture is situated in the posterior third of the urethra, but is chiefly employed where perineal fistulæ are present. It is performed by passing a special shouldered staff (Syme's, Fig. 561), the distal end of which is small enough to traverse the stricture, and grooved in the middle line, whilst the shaft of the instrument is of larger size, and ends abruptly, so that the shoulder rests against the face of the stricture; the groove extends on to the larger portion for about ½ inch. The patient is then placed in the lithotomy position, and the surgeon, seated opposite the perineum, which is shaved and well purified, incises it in the middle line, carrying his dissection carefully downwards so as to reach the groove in the staff behind the stricture. The knife is then carried forwards to the anterior extremity of the groove, and inasmuch as it extends on to the shaft of the instrument, the stricture is completely divided. Any fistulæ which exist are laid open into the median wound, and thoroughly scraped and purified. A full-sized soft catheter is then passed into the bladder, through either the penis or the perineum, according to circumstances, and retained in position for some days, the urine being syphoned off in the usual way, whilst the perineal wound, after all hæmorrhage has been stopped, is packed with strips of antiseptic gauze, and allowed to heal by granulation. The catheter is removed early or late according to the amount of general disturbance caused thereby, and subsequently a full-sized instrument can be passed into the bladder daily.

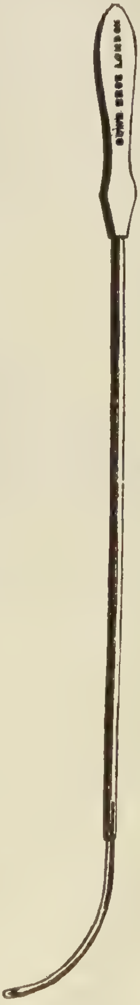

FIG. 561.—SYME'S SHOULDERED STAFF FOR EXTERNAL URETHROTOMY. (DOWN BROTHERS.)

The **Treatment of Impassable Stricture** varies according to whether or not the condition is complicated with retention of urine.

If *no retention is present*, it is possible that the inability to pass an instrument is due to some temporary spasm or congestion induced by errors of diet or drink, or perhaps by exposure to cold. Hence the patient should rest in bed for a few days, his bowels be well opened, the diet regulated, and a mixture containing some alkaline purgative and tincture of henbane administered. Further attempts at instrumentation should then be made, if necessary, under an anæsthetic, and if the stricture still remains impassable, *Wheelhouse's operation* (Fig. 562) is indicated. This consists in incising the urethra in front of the constriction, tracing the passage backwards, and dividing it. A Wheelhouse's straight staff with a median groove and a blunt hook at the end is inserted down to the stricture, and the urethra opened just in front of it by cutting down on the groove. The staff is then twisted round, the upper end of the incision drawn up by the projection of the hook, and the sides of the urethra held apart with artery forceps. The orifice of the stricture is thus exposed, and granulations may often be seen projecting from it. A fine probe-pointed director can generally be insinuated along the urethra through the stricture, which is then divided. A full-sized instrument is passed into the bladder and retained for a few days, whilst the wound is allowed to heal by granulation.

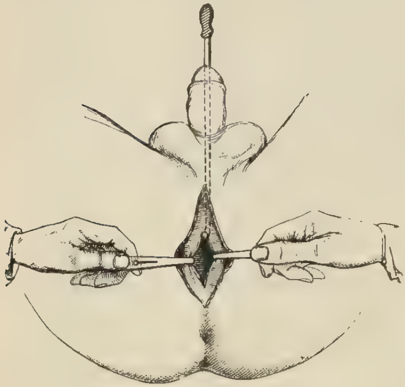

FIG. 562.—WHEELHOUSE'S OPERATION FOR IMPASSABLE STRICTURE. (BRYANT'S 'SURGERY.')

If *retention of urine is present* in a case of impassable stricture, no time must be lost. If seen at an early stage, and the symptoms are not urgent, the patient is given a hot bath, and the bowels are opened by a warm enema, whilst a moderate dose of opium or preferably a morphia suppository is administered. If the urine is not passed naturally in the bath, and the bladder is becoming distended, being felt in the lower part of the abdomen, suprapubic aspiration, or puncture with a trocar and cannula, should be undertaken, and temporary relief thus obtained. Probably, when tension has been removed from the posterior part of the urethra, a catheter will be introduced without much difficulty. Failing this, aspiration may be several times resorted to, but it is generally wiser to open the urethra in front of or behind the stricture, and drain the bladder, since the risks of inflammatory troubles, extravasation of urine, dangerous pressure upon the kidneys, and urinary infiltration along the lines of puncture, are thereby lessened.

Cock's Operation, or **Perineal Section,** is sometimes adopted when no guide can be passed into the bladder (Fig. 563). The patient is placed in the lithotomy position, and the situation of the membranous urethra ascertained by inserting the index-finger into the rectum. A median perineal incision is then made, and after dividing the cutaneous structures, the surgeon plunges the scalpel boldly in towards the apex of the prostate, guided by his finger in the rectum. He must keep strictly in the middle line, so as to avoid the important vascular and other structures which are so abundantly present in the perineum. As soon as the urethra is opened, a gush of urine often escapes; the upper urethral wall should not be damaged with the knife, for fear of opening up the deep pelvic cellular tissue.

This operation may be tolerably simple if the urethra behind the stricture is dilated, as is not uncommonly the case; but sometimes it is extremely difficult, especially if the urethra has been displaced laterally. If the stricture is not situated too far from the incision, it is always wise to complete the operation by dividing it, and a full-sized catheter can then be passed into the bladder, and the perineal wound allowed to granulate. If the stricture cannot be dealt with during the operation, and is of a dense cartilaginous nature, a tube is inserted into the bladder through the perineum; probably at the end of a few days the tissues will yield sufficiently to allow of the passage of a catheter, or Wheelhouse's operation can be subsequently adopted.

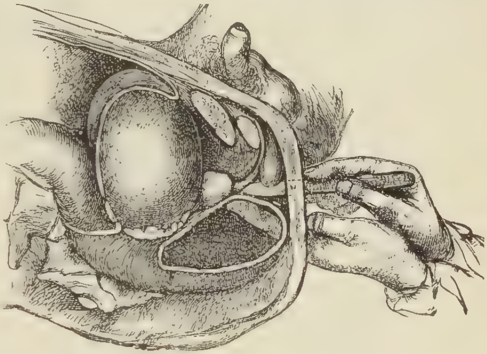

Fig. 563.—Cock's Operation of Perineal Section. (Bryant's 'Surgery.')

The chief **complications** of stricture other than those already mentioned are peri-urethral abscess, perineal fistula, and extravasation of urine.

A **Peri-Urethral Abscess** is due either to a limited extravasation of urine, or to the absorption of infective material through an ulcerated surface. It is indicated by the formation of a hard, brawny swelling in the perineum or above the scrotum, which is tender to the touch. As it approaches the surface, fluctuation can be detected, and the skin over it becomes congested and œdematous. Constitutional disturbance and fever of an asthenic type are also present. Left to itself, it bursts and usually gives rise to a perineal sinus or fistula, discharging either pus or urine mixed with pus. One or many of these fistulæ may occur (Fig. 564), and the openings are not limited to the perineum, but may also be found in the thighs, buttocks, or even the groins. In chronic cases, the scrotal or perineal tissues become infiltrated and of an almost cartilaginous consistency.

Diagnosis.—Every abscess in the scrotum or perineum is not necessarily associated with stricture, for simple irritation of the skin may lead to a superficial abscess; suppuration in the lacunæ, or Cowper's glands, may follow gonorrhœa; a prostatic or ischio-rectal abscess may point in the perineum; whilst the injury inflicted by the passage of instruments, or the existence of false passages, may lead to a similar result.

The **Treatment of a Perineal Abscess** consists in the application of fomentations during the early stages; as soon as pus is present, it should be let out through a free incision, and it is often advisable to take the opportunity of dealing radically with the stricture by section at the same time. Perineal fistulæ can rarely be cured without operation, since, although the stricture may be completely dilated, the discharge of urine and pus continues. Under these circumstances Syme's or Wheelhouse's operation is the proper treatment.

Extravasation of Urine is a condition due to a solution of continuity of the urethral walls, allowing the urine to find its way into the perineal and scrotal tissues. It usually results from over-distension of the urethra behind a neglected stricture; during some violent effort at micturition, the patient experiences severe pain and a sensation as if something had given way in the perineum, followed by a feeling of relief. This, however, is of short duration, as it is soon succeeded by the local and constitutional effects of extravasation. Occasionally the onset of symptoms is more gradual, being preceded by a peri-urethral abscess, which bursts into the urethra; at each act of micturition the cavity becomes more and more distended with urine; finally the wall yields, resulting in diffuse extravasation. The same phenomena are produced in cases of traumatic laceration of the urethra if the patient attempts to empty his bladder.

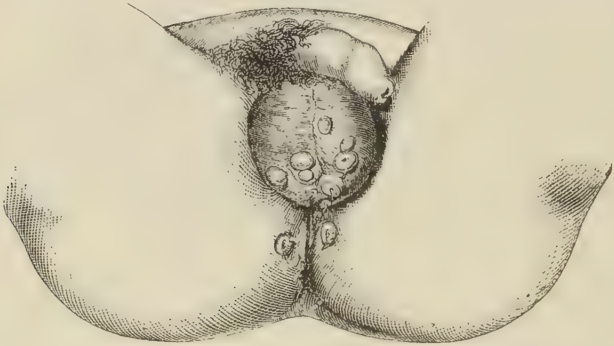

FIG. 564.—PERINEAL FISTULÆ. (BRYANT'S 'SURGERY.')

The membranous urethra is almost always the site of the rupture, the urine finding its way subsequently through the anterior layer of the triangular ligament, and being guided towards the anterior abdominal wall by the arrangement of the fasciæ. The root of the penis, covered by its appropriate muscles, lies in an interfascial cul-de-sac, formed by the anterior layer of the triangular ligament above, and the deep layer of the perineal fascia (or fascia of Colles) below;

these two layers are continuous, passing round the transversus perinei muscles, and are both attached laterally to the ischio-pubic rami. Into this space the urine finds its way, after the anterior layer of the triangular ligament has yielded, and owing to the fact that its passage backwards and laterally is checked by the attachment of the fasciæ, it is necessarily forced forwards, infiltrating in order the perineum, scrotum, and body of the penis. If more extensive, it travels along the spermatic cords to the anterior abdominal parietes, its passage downwards into the thighs being prevented by the attachment of the deep layer of the superficial fascia of the abdomen to the fascia lata just below Poupart's ligament. In the most severe cases the urine may even find its way as far as the axillæ.

The **Effects** of extravasation of urine are always serious. Possibly, if the urine were pure and aseptic, part of it might be absorbed; but even then prolonged infiltration of the tissues is likely to result in suppuration and sloughing. In cases of stricture, however, the urine is almost certain to be foul and alkaline, and hence wherever it travels it gives rise to a gangrenous cellulitis. The parts at first become infiltrated and brawny, but soon emphysematous crackling and putrefaction are observed, owing to necrosis of the cellular tissue. The congested and œdematous skin turns to a dusky purple or black colour, and finally gives way or separates, allowing exit to a mixture of pus, urine, and decomposing slough of a most offensive and penetrating odour. The superficial loss of substance may be so extensive as to lay bare both testicles, and even the body of the penis, or part of the anterior abdominal wall. The inflammatory process is necessarily associated with severe constitutional disturbance, at first characterized by high fever and a quick, bounding pulse; but later on the temperature may become subnormal, and the patient profoundly collapsed from toxæmia.

The **Treatment** consists in early and free incisions, so as to give exit to the urine and pus, and to prevent, if possible, the sloughing of the skin and subcutaneous tissues. Every part that the urine has infiltrated must be dealt with in this way; thus the perineum should be incised in the middle line; the scrotum is similarly divided, if need be, down to the urethra, the testicles being laid on either side, but, if possible, this should be avoided. The penis should be incised, if necessary, on either side of the urethra, and along the dorsal surface. It is often possible to expel a large portion of the urine, especially in the scrotum, by firmly squeezing the infiltrated tissues. A full-sized catheter must be passed into the bladder, and to effect this the urethra has often to be laid open and the stricture divided; perineal drainage is always preferable for these cases. The parts should be subsequently dusted over with iodoform, and dressed with warm antiseptic applications—*e.g.*, a charcoal or carbolic linseed poultice, or boracic fomentations. Frequent hip-baths should be employed, and, if practicable, a continuous sitz-bath would be the very best means of treating the case. As soon as the wounds become clean, they should be dressed in the ordinary way to allow them to granulate. The general health of the patient must of course be attended to, plenty of easily assimilated nourishment, stimulants, and quinine being administered.

Urinary Fistulæ are most commonly found in the perineum, scrotum, or body of the penis. They usually result from periurethral suppuration in connection with a stricture, but are occasionally due to other causes—*e.g.*, a lacunar abscess after gonorrhœa, or a prostatic abscess. They vary much in size and number; when the result of a stricture, many may be present (Fig. 564), and great infiltration of the surrounding tissues is usually produced. The **Treatment** of perineal fistulæ has been already in measure described, external urethrotomy being necessary if a stricture exists. Occasionally the perineal wound does not close after such an operation, even when the stricture has been divided; the edges of the fistula should then be pared, and the wound brought together by deep quilled sutures. A catheter should be kept in the bladder for a few days, and the urine regularly drawn off after its removal.

When of small size, and situated either in the perineum or the penis, cure may be determined by cauterizing the passage either with a probe coated with nitrate of silver or by a galvano-cautery, but in other cases some form of urethroplasty is necessary.

Affections of the Penis.

Phimosis, when complete, is a condition in which the prepuce is so long, and the orifice so narrow, that it cannot be retracted behind the corona. It is usually **Congenital** in origin, and may exist to such a degree as to render micturition impossible. More frequently the opening is a very small one (pinhole prepuce), permitting micturition, but leading to irritability of the bladder from the obstruction. In such cases the prepuce is usually adherent to the glans, and considerable irritation is caused by the retention of the smegma secreted by Tyson's glands; this may collect and become so inspissated as to give rise to definite concretions. The child pulls at the foreskin, owing to the itching produced, and thus the symptoms of vesical calculus may be simulated. Attacks of balanitis are also frequent, and should the prepuce be withdrawn, paraphimosis is almost certain to follow. If allowed to remain untreated long enough, distension of the bladder, and even hydronephrosis, may supervene. Not only is this condition in itself a cause of irritation to the individuals affected, but it is often provocative of masturbation; moreover, it is certain to aggravate the symptoms of venereal disease, and there is but little doubt that it acts as a predisposing cause to epithelioma of the penis. Phimosis also occurs as an **Acquired** condition, resulting from the cicatrization of venereal sores.

The **Treatment** of phimosis consists in circumcision. Other methods have been suggested—*e.g.*, dilatation of the prepuce, and merely slitting it up—but they are not satisfactory.

Circumcision should always be performed on children with a long prepuce within the first year of life, since at that time the parts are but slightly developed, the operation is a trifling one, and but little inconvenience is subsequently experienced; the longer it is postponed, the more troublesome does it become. The best method of operating is as follows: The dorsal aspect of the prepuce is put on the stretch by grasping it on either side of the median line with a pair of catch forceps; a director is then introduced between it and the glans, and held exactly in the middle line, and the prepuce slit up with a curved pointed bistoury or scissors. The lateral halves are now separated from the glans, adhesions, if necessary, being broken down; this must be very thoroughly attended to, so as to enable all retained smegma to be removed, and the corona glandis defined. The redundant preputial tissue, both skin and mucous membrane, is cut away on each side by scissors, special attention being directed to the removal of sufficient tissue on the under side to prevent the unsightly projection so frequently seen just below the frænum. In adults several vessels will bleed and require to be ligatured, especially that in the frænum, but in a child the hæmorrhage is trifling. Having carefully trimmed up the edges, and snipped off all ragged corners, so as to render the margins of the wound regular, catgut sutures are inserted to prevent any raw surface being left exposed; in children only a few are required, but possibly a considerable number in adults; a continuous suture should never be employed. The wound is dressed with strips of gauze, and around this a wisp of sterile wool, retained in adults by a narrow bandage. Considerable after-trouble is sometimes experienced from nocturnal erections, which may be so marked and prolonged as to tear through the stitches; to control this the patient's bowels should be freely opened, and he should be kept on a low and unstimulating diet, and bromide of potassium or other sedatives administered. The stitches are usually removed at the end of five days, and the parts are then dusted over with a mixture of powdered boric acid, zinc oxide, and starch, so as to reduce their sensitiveness.

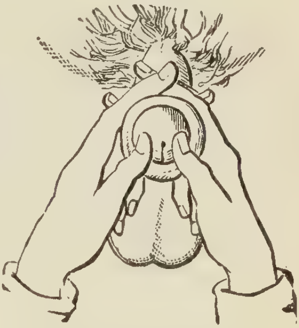

FIG. 565.—REDUCTION OF PARAPHIMOSIS.

When a phimosed prepuce is completely retracted, the patient often finds it impossible to replace it, thus giving rise to a condition known as **Paraphimosis.** It is due to the narrow orifice of the prepuce getting behind the corona, and is characterized by great œdema and congestion, not only of the exposed mucous membrane, but also of the glans itself. If left untreated, ulceration takes place along the line of constriction, and the parts become fixed in their deformed position, the vessels sooner or later accommodating themselves to the new conditions, and the œdema slowly disappearing In some cases sloughing of the glans may occur.

Treatment consists in forcible replacement of the prepuce. This is accomplished by grasping the penis between the first and second fingers of each hand, and compressing the glans penis with the thumbs so as to empty the vessels and diminish the amount of œdema present, and thus reduce its size (Fig. 565). At the same time the fingers draw the prepuce forwards, and thus finally reposition is effected. When the œdema of the prepuce is very marked, it should be punctured in several places to permit the escape of serum and diminish the tension, previous to reduction as just described. In more advanced cases reposition becomes impossible, and then the narrow constricting band caused by the orifice of the prepuce must be divided on the dorsal aspect. This will free the parts, which can be subsequently drawn forwards, and after the œdema has been reduced by applying lotio plumbi for a few days, circumcision may be advantageously undertaken.

Balanitis, or inflammation of the glans, may be simple in nature, arising from want of cleanliness in a person with a long foreskin, but more frequently is associated with gonorrhœa or soft chancres. The under surface of the prepuce is often involved, and then the term **Balano-posthitis** is sometimes applied to it. A muco-purulent or purulent discharge escapes from under the prepuce, which is often swollen and œdematous. Occasionally, when a considerable degree of phimosis exists, the under surface of the prepuce may become ulcerated, and even perforated; whilst in very neglected cases, and especially if phagedena is present, the prepuce will slough, and allow the glans to protrude, usually through its upper surface.

Treatment.—In simple cases, all that is required is to cleanse the parts thoroughly by washing beneath the foreskin, and then apply lead lotion on lint between the glans and the prepuce; but when there is much discharge, and the foreskin is long and swollen, or if perforation is threatening, the prepuce must be slit up, and, after the parts have been restored to a healthy state, the redundant tissues should be cut away by a modified circumcision.

For **Soft Chancre** and **Syphilis,** see pp. 149 and 155.

Herpes not uncommonly affects the prepuce and glans. It may result from simple local irritation, more especially in gouty individuals; but is most frequently seen in patients who have suffered from syphilis, and is then likely to be somewhat intractable. It manifests itself as a crop of small vesicles on a hyperæmic base, which become abraded, leaving a number of small ulcers. It is preceded by pain of a neuralgic type, and accompanied by much itching and irritation. The only treatment required is to keep the parts clean and dust them over with powdered oxide of zinc and starch. In the majority of cases the disease lasts from a week to ten days. During the healing of the herpetic ulcers, a patient is very liable to be inoculated with the virus of either the soft chancre or syphilis if he exposes himself to the risk of infection.

Warts often arise on the penis in the shape of red, vascular excrescences, usually pedunculated, and sometimes of considerable size. They are met with most frequently as a sequela of gonorrhœa, and must be carefully distinguished from mucous tubercles. They should be treated by snipping them away with scissors, and cauterizing the base with a galvano-cautery. The X rays are also useful in their removal when very extensive.

Horns are also occasionally seen arising from the body of the penis. They are of the usual sebaceous type, as described at p. 409, and should be excised.

Epithelioma of the penis rarely arises except in patients who are the subjects of congenital phimosis or possess long foreskins, and hence it is stated that the disease is unknown amongst the Jews. It usually commences in the sulcus behind the corona glandis, and rapidly spreads to the surrounding parts, manifesting itself either as an irregular, papillated, wart-like outgrowth, or as a diffuse infiltration, ulcerating early, and leading to considerable destruction of tissue (Fig. 566). At first the tumour is mainly beneath the prepuce, which becomes distended, producing a sanious discharge, which contains epithelial cells as well as pus corpuscles; but as the case progresses, the prepuce itself is attacked, and even perforated. Later on the body of the penis is invaded, and, owing to its great vascularity, the disease makes rapid progress. The inguinal glands are early affected, but when the body of the penis is involved, the lumbar glands are also implicated.

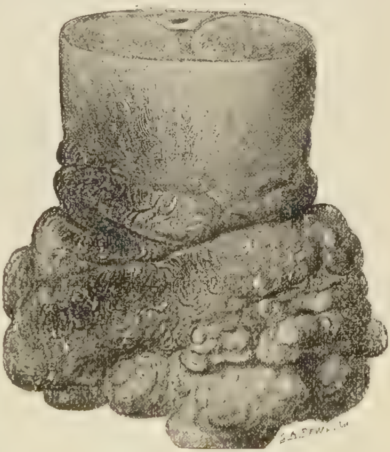

Fig. 566.—Epithelioma of Penis (King's College Hospital Museum.)

The **Diagnosis** of epithelioma from warts is easily made by contrasting the infiltration of the base produced by the former with the soft and normal condition of the glans in the latter affection.

The **Treatment** of epithelioma consists in amputation of the penis whenever the disease is sufficiently limited to lead to the hope that it can be eradicated. When confined to the distal end of the organ, the operation may possibly be performed through the body; but it is much more logical and more in accord with modern scientific dicta to remove the whole organ.

Amputation through the body of the penis is an operation of but little difficulty. The skin around the organ is divided by a circular incision, and retracted a little. The corpora cavernosa are then cut through, and the corpus spongiosum divided half an inch lower down. Bleeding is then arrested by securing the divided vessels; five ligatures are usually required, viz., one for the artery to the corpus cavernosum on either side, one for each dorsal artery, and one for the artery to the septum. The fibrous sheaths of the corpora cavernosa are then overstitched, so as to close the vascular spaces, and the urethra split on its inferior aspect for about a centimetre. The skin on the under side of the penis is similarly incised in a longitudinal fashion, and the urethral mucous membrane is then stitched to it. The remainder of the incision is closed in the usual way.

Amputation of the whole penis is a more serious, but very successful, operation. The patient is placed in the lithotomy position, and the perineum, after being shaved and purified, incised freely in the middle line. The corpus spongiosum is traced backwards, and divided at such a level as to allow the mucous membrane lining the proximal portion of the urethra to be stitched to the skin at the posterior angle of the incision. The corpora cavernosa are freed from their connections, and separated at their origins from the ischio-pubic rami by the knife or suitable raspatories. An elliptical incision is then made round the root of the penis, the dorsal vessels are divided and secured, and the suspensory ligament cut through. The penis can then be drawn forwards, and by a few final touches of the knife completely removed. All bleeding points are ligatured, and the anterior wound closed by a continuous suture in the middle line, a drainage-tube being placed in the perineal portion for a few days. The results of this operation have, on the whole, been very satisfactory, and by the use of a suitable contrivance the patient need not assume the sitting posture in order to micturate. He will require to carry about with him a small metal funnel, bevelled to fit the perineum, and with a spout directed forwards. An excellent one was extemporized by a patient from the rose of a watering-can, the perforated top having been removed and the edges smoothed and bevelled.

CHAPTER XLII.

AFFECTIONS OF THE TESTIS, CORD, SCROTUM, AND SEMINAL VESICLES.

Congenital Affections of the Testis.—It is scarcely necessary to state that the testicles are not developed in the scrotum, but from the posterior wall of the abdominal cavity, so that they lie at first behind the peritoneum close to the kidneys. The body of the gland arises from the so-called genital ridge, which is covered by columnar epithelial cells, and lies to the mesial side of the Wolffian body. The vasa efferentia are developed from the tubules of the latter structure, coming into relation at a later date with the seminal tubules; the vas deferens is formed by the Wolffian duct.

Occasionally the body of the testis is entirely absent, whilst a few cases are on record of absence or deficiency of the vas. Very rarely two testicles have been developed on one side, and have both found their way into the scrotum (*polyorchism*).

The passage of the testis from the abdominal cavity to the scrotum takes place at about the end of the eighth month of intra-uterine life. 'The gubernaculum testis is the active agent in bringing about the descent of the testis. This is a band of involuntary muscular fibres which traverses the inguinal canal, and establishes important connections both within and without the abdominal cavity. Below, three main attachments of the gubernaculum may be recognised, viz.: (*a*) to the abdominal wall; (*b*) to the pubis; (*c*) to the bottom of the scrotum. Above, the gubernacular fibres are chiefly connected with the testicle; but many of them are also attached to the peritoneum on the posterior wall of the abdomen. By the traction which the gubernaculum exerts on the testicle, the descent of that organ is brought about. By the portion attached to the abdominal wall the testicle is pulled down to the internal abdominal ring, the pubic portion drags it through the inguinal canal, whilst the scrotal part finally leads it into the scrotum.

'The formation of the processus vaginalis is accounted for in the same way. Some of those gubernacular fibres which are inserted into the peritoneum drag down the peritoneal diverticulum which lines the inguinal canal and scrotum, and prepares the way for the testicle.' (Cunningham's 'Manual of Anatomy,' second edition, 1896; vol. i., pp. 426, 427.)

Two chief forms of malposition of the testis are described, arising either from its incomplete or abnormal descent.

1. **Incomplete Descent or Retention of the Testis.**—The testis may remain in the abdominal cavity attached to the abdominal wall by a mesorchium (*retentio abdominalis*); more frequently, it is found just within the internal abdominal ring (*retentio iliaca*); but most commonly it occupies the inguinal canal, or lies just outside of it (*retentio inguinalis*). The organ in the latter position is freely mobile, being readily pressed up towards the abdominal cavity. The **Causes** of this condition must be looked for mainly in some abnormal attachment of the gubernaculum, or possibly in the existence of intra-uterine peritonitis. Less commonly a contracted condition of the external abdominal ring, or an unduly large epididymis, may determine its occurrence.

The condition is easily recognised by the absence of the testicle in the scrotum, and in the inguinal variety the organ can usually be detected as a small moveable swelling about the size of a horse-bean, giving the characteristic testicular sensation on pressure. The scrotum on the affected side is imperfectly developed.

In any of these varieties a late descent of the testis may occur, usually accompanied by a congenital hernia, possibly of an interstitial type.

2. **Malposition of the Testis.**—Two distinct forms are described: (*a*) *Ectopia Perinealis.*—In this variety the testis finds its way into the perineum, slipping along the groove between the thigh and the scrotum. It may exist as a congenital condition, being then due to the contraction of an accessory band of gubernacular fibres; or it may happen in consequence of a late descent of the testicle, owing to atrophy of the scrotum. It always causes considerable inconvenience to the patient, especially on sitting or riding. (*b*) *Ectopia Cruralis.*—The testicle here lies on the inner side of Scarpa's triangle, in the region of the saphenous opening. It is said to escape along the crural canal, but more probably it passes down the inguinal canal as usual, and then finds its way over Poupart's ligament to this situation, guided by a second accessory band of gubernacular tissue. When, as not uncommonly happens, a congenital hernia also exists, it may travel outwards to the anterior superior spine, being directed there by the arrangement of the fasciæ, as in a femoral hernia (extra-parietal interstitial hernia, p. 1093).

In cases of retained or misplaced testis the spermatogenic function of the organ is rarely developed, or at most merely for a year or two about the age of twenty. Pain is not unfrequently complained of, coming on in bouts which last for a short time and then disappear, probably due to slight injuries or torsion. Fibrosis of the testis follows in time, and total degeneration is the ultimate outcome. If only one organ is affected, but little harm follows; but if both are involved, the individual is probably sterile.

Complications of a Retained or Misplaced Testicle.—Any of the conditions to be described hereafter in this chapter may involve a retained or misplaced testicle, just as if it were in the scrotum, and give rise to considerable trouble, especially when the organ is lying in close proximity to the peritoneum. A testis misplaced or retained in the inguinal canal is much exposed to injury, and a subacute traumatic orchitis often occurs. It is stated that such organs are very prone to become the seat of malignant disease at a later period of life, but the accuracy of this statement is a little doubtful.

Treatment.—Taking into consideration the discomfort occasioned by this condition, as well as the risk arising from the tendency to malignant disease, there can be little doubt that the best method of treatment is the removal of the testicle. Many operations have been devised with the idea of placing the organ in its normal position in the scrotum, but the majority of such methods have proved useless, owing to the defective length of the spermatic vessels and cord; moreover, the traction and handling required to draw the organ down into the scrotum may determine the occurrence of fibrotic changes, even if they are not already present. Some authors advise the replacement of the organs in the abdominal cavity in patients before the age of twenty-three, but it is doubtful whether much value is to be attached to such a suggestion.

Another condition met with congenitally is **Inversion** of the testis, the epididymis lying in front, and the body of the organ behind. It is of no clinical significance, except that in careless hands the testis may be injured whilst tapping a hydrocele.

Torsion of the Spermatic Cord results in acute strangulation of the testis. The cause still remains unknown, but several of the cases recorded have been associated with late descent of the testicle, and others have been attributed to twists and strains. The symptoms are tolerably characteristic: the patient complains of an acute sickening pain in the testis which persists until gangrene has supervened, and may then disappear; it is accompanied by a certain amount of pyrexia, and the appearance of a tumour, either in the inguinal region or in the scrotum. The testicle, slightly enlarged, is felt below, and above it a larger mass, consisting of the twisted cord and the congested and swollen epididymis. In some cases the latter swelling has been crepitant, owing to the development of gases due to its putrefaction. The condition is very likely to be mistaken for a strangulated hernia, which it closely resembles; but the presence of fever, and the absence of abdominal distension and of fæcal vomiting, are important distinctive signs; moreover, constipation, though often present, is never absolute. If the testis is situated in the scrotum, the cord and inguinal canal are found to be clear; whilst if in the canal, the affected side of the scrotum is empty. The only **Treatment** possible is exploration and removal of the inflamed or gangrenous testis and cord, unless the case is seen very early, when it may be feasible to untwist it.

Injuries of the Testis and Cord.—**Contusion** is a very common form of injury. It arises from blows, kicks, squeezes, and the like, and is always associated with immediate pain of a most sickening and intense character, which is not only experienced in the testicle, but also radiates along the cord towards the loins and back, and down the front of the thigh. Severe shock accompanies the pain, and may be so profound as to lead to a fatal issue. A well-marked traumatic orchitis often follows, and this may in turn induce atrophy of the organ, although the same condition sometimes occurs without much evidence of inflammation, as a result of thrombosis and occlusion of the spermatic vessels. A hæmatocele is also induced by a subcutaneous lesion of this nature. **Treatment** consists in keeping the patient in the recumbent posture with the scrotum well raised, and in applying fomentations or an icebag.

Penetrating Wounds or **Punctures** are uncommon except as a result of surgical treatment (*e.g.*, tapping a hydrocele). A certain amount of hæmorrhage usually follows, whilst the immediate lesion is associated with severe testicular pain. If the wound becomes infected, the tubules are likely to protrude, and a hernia testis may result. All that is ordinarily required is to purify the parts and allow them to heal; sutures should not be inserted into the tunica albuginea, if there is any doubt as to the wound being sterile. If the gland is totally disorganized, castration must be undertaken.

Hæmatocele, or a localized collection of blood in the tunica vaginalis or cord, is a common result of injuries.

1. **Hæmatocele of the Tunica Vaginalis** arises from traumatism, such as a sudden blow or severe strain, and occasionally follows the tapping of a hydrocele if a superficial vessel has been ruptured or punctured, or if the body of the testis has been wounded; it may, however, be due to general oozing from dilated capillaries in the serous membrane owing to the sudden relief of tension. It also occurs more or less spontaneously in connection with malignant disease. The **History** generally given is that the patient was seized with a sudden sickening pain in the testicle, which became quickly enlarged without any evidence of inflammation. If blood is extravasated at the same time into the scrotum, the integument becomes discoloured in the course of a few days owing to a diffusion of the blood pigment. At first the swelling is smooth and fluctuating, exactly resembling a hydrocele, except in the absence of translucency; but owing to a deposit of fibrin on the walls from the coagulation of the blood, it becomes hard and firm in a short time

closely simulating a solid tumour. In slight cases the blood is entirely absorbed, but when the effusion is considerable the coagulum is likely to persist. On laying open such a swelling, the testicle is usually found in a healthy state, whilst the enlarged tunica is occupied by some blood-stained brownish-yellow fluid, and surrounded by a mass of fibrinous coagulum, part of which is deposited in laminæ upon the walls, and part remains as shreddy masses projecting into its lumen. In very chronic cases the walls of the tunica become thick and indurated, and may even undergo calcareous changes. Suppuration is sometimes met with as a result of auto-infection. The **Diagnosis** of a hæmatocele in the earlier stages is easily made; but when it has solidified it can only be suspected by the history, and by the exclusion of other sources of enlargement, whilst an exploratory incision or puncture is often necessary to settle the diagnosis. **Treatment.**—When the patient is seen soon after the injury, he must be kept at rest, the parts elevated, and evaporating lotions applied; whilst if the effusion is large, removal of a portion by aseptic tapping will expedite the process of absorption. In more chronic cases it may be necessary to lay the cavity open and remove its contents, whilst in the later stages, if the tunica has become thick and indurated, and the testis atrophied, castration may be advisable.

2. **Hæmatocele of the Cord** is but rarely seen. It is due to the rupture of one of its vessels, as a result of injury or strain. A swelling of considerable size rapidly forms, extending along the cord from the inguinal region to the scrotum, but the testis remains free and unimplicated. Such a condition may be mistaken for an omental hernia, but on careful examination the tumour is felt to be more uniform in consistency, more rounded in outline, and even semi-fluctuating. It is irreducible and without impulse, whilst the history of the case will assist the surgeon in making a correct diagnosis. **Treatment** in the early stages consists in the application of evaporating lotions, and later on, if the blood-clot is not absorbed, the cavity may be laid open and the coagulum removed.

Rupture of the Vas Deferens has resulted from excessive strain; it is, however, very rare, not more than half a dozen cases being on record. It may affect the intra-abdominal portion of the vas, and then gives rise to hæmorrhage from the urethra, together with some amount of fever and hypogastric pain, leading possibly to atrophy of the organ. Rupture of the scrotal portion is followed by enlargement of the testis, and perhaps scrotal hæmorrhage. This was associated in a case under our observation with hæmorrhage from the urethra on attempting coitus shortly after the accident, and subsequently with severe pain and swelling of the testis produced by the same act, but atrophy did not follow. If it occasions any inconvenience, it is best treated by castration.

Inflammatory Affections of the Testis may be chiefly confined at their onset either to the body of the organ or to the epididymis; in the former case the term **Orchitis** is applied to it, in the latter **Epididymitis**; as the case progresses both portions are involved in the process; either condition may be acute or chronic.

Acute Orchitis most frequently results from injury, but it is also met with as a primary affection in gouty and rheumatic individuals, sometimes arising spontaneously; or it may follow mumps, typhoid, or other eruptive fevers, as a result of metastasis, whilst it is always to some extent associated with epididymitis. In mumps it may precede the parotid lesion, or may even occur without it.

The testicle becomes considerably enlarged, exceedingly painful, and tender to the touch. The shape of the organ is more or less globular (Fig. 567, A), whilst the pain is of a peculiarly sickening character, extending upwards along the course of the cord towards the back and loins. The scrotal integuments become red and infiltrated, and, owing to the acuteness of the process, more or less adherent to the coverings of the gland. A plastic or serous effusion into the tunica vaginalis is sometimes present, giving rise to what is known as an 'acute hydrocele.' Some constitutional disturbance accompanies the process, the temperature being elevated two or three degrees, whilst vomiting and constipation are marked symptoms. It is unusual for suppuration to ensue, but an abscess occasionally forms, and then, after the pus has been let out, a hernia testis may follow. Atrophy is a more common sequela, especially in adults, being caused by constriction of the vessels and tubules, owing to organization of the inflammatory exudation.

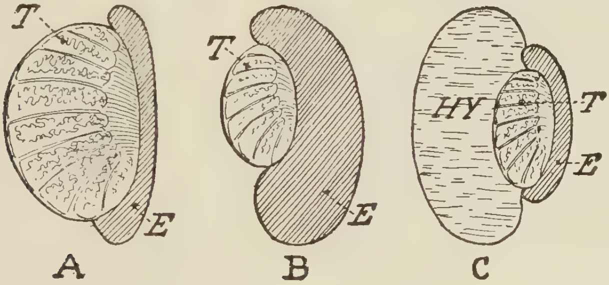

FIG. 567.—DIAGRAMMATIC SECTIONS OF (A) ORCHITIS, (B) EPIDIDYMITIS, AND (C) HYDROCELE OF TUNICA VAGINALIS.

T, Testis; *E*, epididymis; *HY*, hydrocele.

Acute Epididymitis is almost always due to the extension of an inflammatory process from the urethra, the usual cause being gonorrhœa; it occasionally follows the passage of instruments or the lodgment of a calculus; or it may be secondary to a suppurative prostatitis, unconnected with gonorrhœa. It is ushered in by pain in the inguinal region and perhaps in the hypogastrium along the course of the vas deferens, which soon extends to the scrotum.

The testicle becomes enlarged, but its shape is that of an elongated oval, somewhat flattened laterally. The epididymis is readily felt as a crescentic swelling, partially overlapping the gland in all directions, and in its concavity the rounded outline of the anterior wall of the testis can usually be distinguished (Fig. 567, B), or the tunica vaginalis distended with fluid. The scrotum is red, œdematous, and adherent to the testis, whilst the cord is infiltrated, enlarged, and tender. The same constitutional symptoms are met with as in orchitis. Suppuration is perhaps more common than after the latter affection, since the condition is usually due to a suppurating inflammation of the deeper parts of the urethra; but it is a rare complication. Atrophy of the testis is a not unfrequent result in cases which are not efficiently treated, the plastic material exuded into the epididymis being organized into fibro-cicatricial tissue, and constricting the spermatic vessels; an acute attack of double epididymitis may in this way render the individual sterile.

The **Treatment** of both these conditions in the acute stage consists in keeping the patient in bed, with the scrotum supported on a small pillow. The part is assiduously fomented, except when the case is seen very early, an icebag or Leiter's coil being then employed. Leeching should not be utilized, as the triangular leech-bites are very liable to become irritated and infected, and never heal well in the scrotum; if local abstraction of blood appears desirable, one or more of the scrotal veins may be punctured; the hæmorrhage is easily arrested by elevating the part. Pain, if severe, may be mitigated by a hot sitz-bath, or by morphia suppositories. As regards general treatment, the patient, after a preliminary dose of calomel, is kept on a fluid, unstimulating diet, whilst alkaline purgatives are administered, with the addition of tincture of henbane or opium as a sedative; if the pulse is hard and the temperature high, vinum antimonialis in 10-minim doses is also beneficial. When the acute stage is passed, the organ usually remains enlarged, and for a time somewhat tender; it is then best treated by strapping with lead plaster, or with the emplastrum ammoniaci cum hydrargyro. This must be continued until all signs of thickening and induration have disappeared.

Subacute or **chronic** forms of inflammation are also met with affecting the testis or epididymis, either as a consequence of the above, or resulting primarily from blows or strains. The characteristic enlargement is readily detected, associated with a certain amount of tenderness. A useful diagnostic point between the chronic epididymitis following gonorrhœa and that due to syphilis is that the former usually involves the globus minor, and the latter is almost limited to the globus major. The condition is best treated by strapping, and perhaps the administration of small doses of mercury and iodides may assist in the absorption of the inflammatory products. Chronic orchitis is very similar to the enlargement produced by syphilis, from which, indeed, it can only be distinguished by the absence of a syphilitic history.

Tuberculous Disease of the Testis (*Syn.:* **Tuberculous Sarcocele, Chronic Tuberculous Orchitis**).—This affection is most commonly seen in young adults with a distinct tuberculous history, but it also occurs in otherwise healthy individuals. It may commence as a primary affection of the epididymis, or may be secondary to tuberculous disease elsewhere.

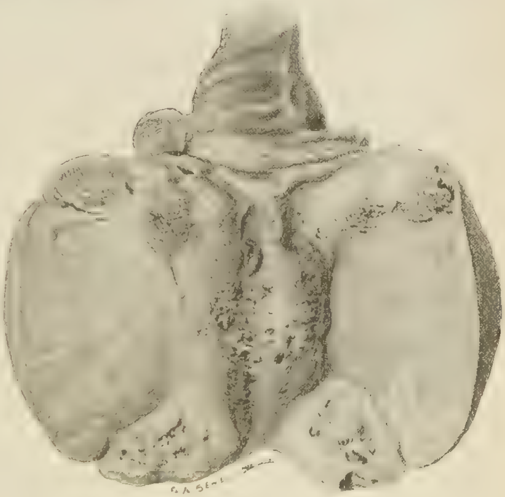

FIG. 568.—TUBERCULOUS DISEASE OF TESTIS, MAINLY INVOLVING THE EPIDIDYMIS AND CORD. (KING'S COLLEGE HOSPITAL MUSEUM.)

Pathological Anatomy.—The process originates in the connective tissue of the epididymis, and runs its usual course, at first consisting merely of miliary elements deposited around the vessels, which by their coalescence and caseation lead to the formation of cheesy masses, and these at a later stage may emulsify and give rise to abscesses. It may be limited to any one part of the epididymis (most often the globus major), or may widely infiltrate its substance, causing a general enlargement (Fig. 568). In the latter case it early tends to spread, either into the body of the testis or along the vas deferens. The corpus Highmorianum becomes first involved by a similar deposit, and finally the intertubular connective tissue of the gland; this is always associated with overgrowth of the epithelium in the tubuli seminiferi, the cells after a time undergoing fatty degeneration, and perhaps to such an extent that, on microscopic section, the normal appearance of the organ has entirely disappeared. An abscess may form within it, and find its way to the surface by burrowing through the tunica albuginea, the visceral and parietal layers of the tunica vaginalis having previously become adherent. After the pus has escaped, a hernia testis is likely to develop. If the process extends upwards along the cord, the vas is mainly implicated, becoming perceptibly thickened, the other structures of the cord being but little affected. The disease spreads along the vas on the outside of the bladder to the vesiculæ seminales and prostate, and may even involve the base of the bladder, the ureters, and kidneys. Lastly, general dissemination of tuberculous disease may occur, and it is a curious fact that meningeal mischief is not very uncommonly associated with genital tuberculosis.

Clinical Signs.—The disease is generally unilateral, although the other testicle often becomes involved at a somewhat later date. Its onset may be abrupt or gradual; in the former case the attack simulates an acute orchitis, but at the end of a few weeks, although the pain subsides, the swelling persists, being followed by the development of abscesses containing cheesy pus. In the more chronic cases, one or more firm and indurated nodules, which are free from tenderness, are felt in the epididymis, but more often the whole of this structure is found to be enlarged and thickened, forming a painless crescentic swelling, surrounding the posterior half of the body of the testis, from which it is usually separated by a deep groove or sulcus. The epididymis is nodular and craggy to the feel, and may be of unequal consistency, areas of softening being interposed between portions which are distinctly hard. The vas is early thickened, whilst the other structures of the cord are but little involved; the thickening is more or less nodular, and almost beaded in its consistency. The body of the testis may be involved and enlarged, the line of demarcation between it and the epididymis becoming indistinct. Testicular sensation remains as long as any normal glandular tissue exists, but effusion into the tunica vaginalis is not usual. When suppuration occurs, the pain increases, especially if the abscess is in the substance of the organ. As it finds its way to the surface, the skin becomes adherent to the testis, and is red and congested. Gradually fluctuation manifests itself, and the escape of the pus may be followed by a hernia testis. An abscess forming in connection with the epididymis is less painful, and may attain considerable dimensions before it bursts; it never gives rise to a hernia testis. Extension of the disease to the seminal vesicles causes no characteristic symptoms, and is only detected on rectal examination; when, however, the base of the bladder and prostate are affected, considerable dysuria and irritability of the bladder are induced.

The differential diagnosis is discussed at p. 1296.

Treatment.—If seen in the very early stage, when only a small nodule exists in the epididymis, it is possible that residence at the seaside or at a suitable sanatorium, combined with constitutional treatment (perhaps vaccination with tuberculin) and local strapping to induce venous congestion, may lead to its disappearance. If apparently limited to one portion of the epididymis, the disease may be dealt with by the conservative measure of incision, curetting, and applying pure carbolic acid; but such is seldom feasible, since the disease is seldom sufficiently localized.

If the whole epididymis is enlarged and solid, and the body of the testis more or less normal, *epididymectomy* may be undertaken. In this procedure the tuberculous mass is freed from the body of the organ, the spermatic vessels lying on the inner side are carefully guarded, and the vas is dissected out and cleared as high as possible. The presence of an abscess or sinus is no contra-indication, since it merely involves a somewhat freer removal of scrotal integument. Should foci exist in the body of the testis, they are likely to atrophy subsequently, or they can be scraped out at a later date. In this way the function of the gland as the producer of a valuable internal secretion can be retained, although its use as a generative organ is lost—a retention the more important owing to the likelihood of the other testis being subsequently invaded. If the vas is thickened at the external abdominal ring, it need not deter the surgeon from operating, even if the vesiculæ are enlarged, since tuberculous disease is not like cancer; if the great bulk of the mischief is removed, Nature can frequently eliminate any small portion that remains. In such cases the inguinal canal should be freely opened, and the vas traced backwards and divided. In one case thus dealt with, the bladder was distended with boracic lotion, the patient placed in the Trendelenburg position, and the vas followed back along the side of the bladder nearly as far as the seminal vesicles. For tuberculous disease of the seminal vesicles, see p. 1297.

Castration (p. 1296) is reserved for cases where the testis is disorganized, and its value as a secreting gland totally destroyed. Of course the cord is also removed after division as high up as possible.

Syphilitic Disease of the Testicle.—The testicle may become affected by syphilis, either in the late secondary or in the tertiary stage; most commonly it results from the acquired variety, but occasionally is met with in the inherited.

Secondary Syphilitic Epididymitis is not very frequently seen. It occurs in the form of a chronic enlargement of the epididymis, associated perhaps with a hydrocele, about six to twelve months after infection. The case is very similar to a simple chronic epididymitis, but the nodular thickening mainly involves the globus major, and is usually symmetrical. It readily disappears on the administration of mercury.

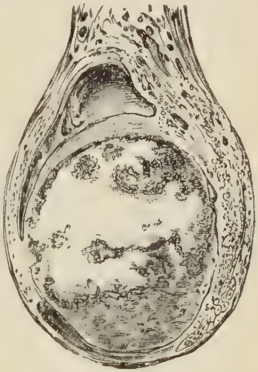
FIG. 569.—TERTIARY SYPHILITIC DISEASE OF TESTIS WITH GUMMA OF THE BODY. (TREVES' 'SURGERY.')

Tertiary Syphilitic Orchitis is observed at a much later period of the disease, even twenty or thirty years after infection. It is not unfrequently bilateral. **Pathologically,** it resembles the majority of tertiary manifestations in consisting of a diffuse infiltration accompanied by overgrowth of the connective tissue. If the process affects equally the whole organ, the ordinary syphilitic sarcocele or sclerosis of the testis results; if it is more localized in its distribution, the gummatous variety is said to be present (Fig. 569). The former affection is much more common than the latter.

In the tertiary syphilitic sarcocele, the body of the testis is primarily involved, and becomes evenly enlarged and stony hard. It is globular in outline, frequently accompanied by a hydrocele, and the normal testicular sensation early disappears. The same process occasionally extends to the epididymis and cord. Suppuration is exceedingly rare. On section the characteristic appearance of a testicle has entirely vanished; the tunica albuginea is much thickened, and extending from it through the substance of the organ are bands of connective tissue, representing the normal septa; in bad cases the gland substance is almost completely destroyed.

In the *gummatous* variety a similar condition involves the greater part of the organ, but in addition one or more gummatous foci are present. On section they appear as yellowish-white masses, fairly well defined, and since the central portions are non-vascular, they undergo the usual degenerative changes, becoming soft and diffluent. If the gumma comes to the surface, the skin may give way, and a deep syphilitic ulcer with a sloughy base like wet wash-leather results. Hernia testis very rarely follows such an occurrence. The clinical features of the gummatous variety are at first similar to those of the former, but after a time one portion of the organ becomes prominent and painful, and as this increases in size the central parts become soft and fluctuating, and finally yield, giving exit to the characteristic gummy contents. Under suitable treatment the swelling in each of these varieties may disappear entirely, leaving the testicle either of normal size or atrophied; but, as in tuberculous disease, its functional utility, if not entirely destroyed, is probably impaired considerably.

For the differential diagnosis, see p. 1295.

Treatment consists in the administration of iodide of potassium and mercury, whilst the hydrocele may be tapped, and the organ strapped or supported by a suspender. If a gummatous ulcer is produced, it may be possible to excise the greater portion of the characteristic slough at its base; but in all cases it should be dressed with lint or gauze steeped in lotio nigra or some other mercurial preparation.

Hernia Testis is the term applied to a protrusion of the substance of the gland, more or less infiltrated with granulation tissue, through an opening in the tunica albuginea and skin of the scrotum. It arises from various causes, such as a septic penetrating wound of the testis, acute suppurative orchitis, or from a chronic abscess, whether simple or tuberculous in nature. It is rarely produced by the breaking down of a gumma, owing to the extensive infiltration of the organ with fibro-cicatricial tissue, and necessarily it never follows suppuration in the epididymis. It is always preceded by a condition of increased pressure within the tunica albuginea, and consequently as soon as an aperture is formed in this membrane, its natural elasticity, allowing of its contraction, forces a portion of its contents out of the opening; this may even proceed to such an extent as to cause the whole of the substance of the gland to protrude, the tunica albuginea being practically turned inside out. A mass resembling granulation tissue is then seen to project through an opening in the scrotum; it is often somewhat pedunculated or mushroom-like in shape, possibly overhanging the margins of the skin, but in less advanced cases the integument may be distinctly undermined. A considerable discharge of pus usually accompanies it. The condition must be distinguished from the fungating growth which occasionally results from malignant disease of the organ, when the protrusion consists of tumour substance, with no trace of testicular tissue.

The **Treatment** of hernia testis usually consists in extirpation of the organ, especially when it is affected by tuberculous disease. In simple cases healing of the wound may be obtained by keeping the part aseptic, and applying pressure by means of a pad of gauze. In other cases it may be possible to separate the protruding mass from the surrounding skin, and after paring the edges of the wound, to bring them together by sutures, and thus bury the gland substance, which, however, remains projecting from the opening in the tunica albuginea. Such proceedings are seldom very satisfactory.

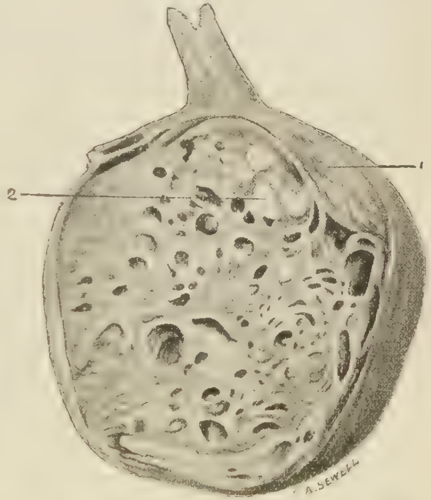

FIG. 570.—FIBRO-CYSTIC DISEASE OF THE TESTIS (COLLEGE OF SURGEONS' MUSEUM.)

1, Body of testis spread out over the growth; 2, nodules of cartilage contained in the growth.

Tumours of the Testis are generally malignant in character, only one non-malignant form being at all common, viz., fibro-cystic disease, or adenoma testis.

Fibro-Cystic Disease (*Syn.:* **Adenoma Testis, Cystic Sarcocele**).—This condition is characterized by the formation of a tumour of variable size, scattered through the substance of which are numerous cystic cavities, lined with cuboidal or stratified epithelium. These cysts are usually rounded, but occasionally tubular in shape, and may communicate with one another; they contain serous fluid and sometimes intracystic growths. They are surrounded by connective tissue, the amount and character of which vary greatly in different cases. It consists mainly of simple fibrous tissue, but it is very common to see cartilaginous nodules (Fig. 570, 2) and myxomatous foci scattered through its substance, and is very prone after a time to undergo a malignant transformation. According to Bland-Sutton and Eve, these tumours arise from the remains of the Wolffian body or mesonephros, which is almost always normally represented in the neighbourhood of the globus major of the epididymis by the structure known as the organ of Giraldès (paradidymis). Others look on the disease as a teratoma. The testicle can be found in most cases spread out in a thin layer over the tumour substance (Fig. 570, 1).

Clinical Signs.—This condition is met with in young adults, and may possibly be attributed to an injury. The organ steadily becomes enlarged, but this gives rise to no inconvenience except by its size and weight. It is round in outline and elastic in consistency, the cord remaining unaffected unless malignant disease supervenes. When of great size, the skin of the scrotum may ulcerate. The case runs a chronic course, and even should the growth become malignant, the change of type only appears late in the disease.

Treatment consists in removal after an exploratory incision has demonstrated the nature of the growth.

Other non-malignant tumours have been described, such as chondroma, osteoma, fibroma, myxoma, etc., but they are exceedingly uncommon, if they occur at all apart from sarcoma or fibro-cystic disease.

Sarcoma of the Testis commences in the body of the organ, either within the first decade of life or between the ages of thirty and forty, and is sometimes a sequela of late or imperfect descent. It is usually a soft, round-celled growth, taking on the form of a lympho-sarcoma; in other cases it is harder, and of the nature of a fibro-sarcoma. Frequently cartilaginous nodules are incorporated in its substance, and patches of myxomatous tissue or cystic degeneration from hæmorrhage are also seen. As already stated, it is sometimes secondary to fibro-cystic disease. It originates in the connective-tissue elements of the organ, the glandular substance being early destroyed. It appears as a rounded swelling, and at first its outline is irregularly smooth; as the disease progresses, however, it may become nodulated from the development of cysts. The tumour may attain very large dimensions, but the cord and scrotal tissues only become affected in the later stages, and then ulceration and the formation of a fungus testis occasionally follow with involvement of the inguinal lymphatic glands. Secondary growths are always found in the lymphatic glands which lie over the bifurcation of the aorta and vena cava, and thence the disease is disseminated locally and may cause severe pain by involvement of the nerve roots of the lumbar plexus, or give rise to visceral deposits. There are but few subjective symptoms at first, a feeling of weight and dragging being alone experienced, whilst testicular sensation is soon lost; but at a later date, when the cord is involved, pain and cachexia become very marked. The **Course** of these cases is slow up to a certain point, but the tumour may then rapidly increase in size, spreading along the cord to the interior of the abdomen even in the course of a few weeks, thereby rendering removal utterly impossible, although it would have been easily practicable at an earlier period. **Treatment** consists in the extirpation of the growth with the testis as early as possible, the cord being divided high up.

Carcinoma of the Testis is usually of the encephaloid type, and arises in the body of the organ as a soft rapidly-growing tumour, which soon extends to the tissues of the cord, and contracts adhesions to the scrotum; ulceration and the formation of a fungating mass follow, whilst secondary deposits are found in the abdominal and inguinal glands as in sarcoma, and sometimes in the viscera. It is impossible to distinguish a carcinoma from a sarcoma of the testis by clinical signs, since it usually occurs at the same period of adult life, and very rarely in children. Very rapid growth, and early enlargement of the cord and lymphatic glands, point to cancer rather than sarcoma. The only **Treatment** is removal of the diseased organ, including the spermatic cord, as high as possible, and the incision may advisably be carried up along the line of the iliac vessels with stripping aside of the peritoneum and its contents so as to allow of the exposure of the bifurcation of the aorta and the removal of any enlarged glands in that position—a serious addition to the operation, but essential, if the patient's life is to be saved. The outlook is anything but favourable, and becomes still less so if the glands in the groin are involved.

Hydrocele.—Any collection of fluid, other than pus or blood, in the neighbourhood of the testis or cord is termed a hydrocele. The fluid usually consists of serum, but in some forms spermatozoa are also present, and in rare cases it may consist of chyle or a similar milky fluid (chylous hydrocele). Two chief varieties are described, according to whether the testis or the cord is involved.

I. In **Hydrocele of the Testis** the fluid is contained in the tunica vaginalis (vaginal hydrocele), or exists as a circumscribed swelling in its neighbourhood (encysted hydrocele).

1. A **Vaginal Hydrocele** is one in which there is an accumulation of fluid in the tunica vaginalis, and the following varieties may be differentiated:

(*a*) *Acute Hydrocele* occurs in conjunction with acute inflammation of the testis or epididymis. The effusion of fluid is never abundant, and is often only made out on careful examination; at first it consists of plasma, as in all acute inflammations of a serous membrane, and is therefore spontaneously coagulable. It may become chronic, or may disappear entirely, perhaps leaving a few adhesions.

(*b*) A *Congenital Hydrocele* occurs in cases in which the funicular process is still patent. The general signs of a vaginal hydrocele, as described below, are present, but the fluid can be returned by pressure into the abdominal cavity. It is rarely seen in others than infants, and may be treated by the application of evaporating lotion to the scrotum, whilst a light truss or woollen support is placed over the inguinal canal, as for congenital hernia. It is often associated with phimosis, which should, of course, be dealt with by circumcision. If it persists, it may be treated by operation as for congenital hernia, to which, indeed, it frequently leads.

(*c*) An *Infantile Hydrocele* is due to non-obliteration of the funicular process of peritoneum, except at its upper extremity. It presents the signs of an ordinary acquired hydrocele, the fluid, however, extending along the cord, even into the inguinal canal. Its treatment is the same as for an acquired hydrocele.

(*d*) A *Bilocular Hydrocele* is one in which there is an additional loculus within the abdominal cavity, communicating by a neck of variable size with the distended tunica vaginalis. It is due to a persistence of the intra-abdominal portion of the funicular process between the peritoneum and internal abdominal ring; this becomes distended with fluid, and the collection burrows downwards in front and by the side of the bladder towards the pelvis. A similar condition occurs in the female, arising in the upper part of the canal of Nuck.

(*e*) *Acquired Vaginal Hydrocele* is the most common variety. **Causes.**—It may arise in middle-aged persons without any apparent cause, but is usually associated with chronic orchitis. A hydrocele almost always accompanies a tertiary syphilitic enlargement of the organ, but is uncommon in tuberculous or malignant disease. Hydrocele is very frequently seen in those who dwell in hot climates, probably as the results of a lax and pendulous condition of the scrotum and testicles; in India natives always support the scrotum. The tunica is usually thickened and hyperæmic, and that covering the testis may be pitted and scarred. Here and there thick plaques of fibrous material are visible, sometimes yellowish from fatty degeneration, sometimes calcified, or even cartilaginous or osseous.

Signs.—Vaginal hydrocele appears as a rounded pyriform swelling in the scrotum, which extends for a variable distance along the cord. Its tension differs with the amount of fluid present, and with the thickness of its walls; it is generally elastic, and with obvious fluctuation. The cord is felt distinctly above the rounded upper part of the tumour, and the testis is generally situated posteriorly (Fig. 567, C), although it projects forwards into the cavity, and is thus not readily detected. Its position may be ascertained by pressure over it, when the characteristic testicular sensation is produced. On holding a light close to the scrotum, the tumour is seen to be translucent, and the position of the testicle can also be demonstrated. In old-standing cases when the walls have become exceedingly thick, the translucency will be lost. Occasionally, when inflammation has existed, adhesions may form between the testis and the anterior wall, and irregularity in the shape of the tumour is thereby induced, or the cavity may be divided into compartments by fibrous bands or septa.

As a result of traumatism, subcutaneous rupture of a hydrocele has occurred, leading to increased swelling of the part, and perhaps œdema of scrotum and penis; the parts become bruised, but after a time the swelling diminishes, and perhaps a spontaneous cure follows.

It is scarcely necessary to mention that there is no impulse on coughing, and that the tumour is dull on percussion. When the distension is very great, its weight causes a dragging pain; the penis becomes buried in the swelling, and eczema of the scrotum may result from the urine trickling over it. The *fluid* in the sac is yellowish or straw-coloured; its specific gravity varies from 1015 to 1025; it contains a large amount of albumen, especially fibrinogen. In old-standing cases cholesterine may also be present.

The **Treatment** of vaginal hydrocele is palliative or radical. **Palliative** treatment consists in tapping the cavity and removing the fluid, the patient being subsequently directed to wear a suspender, and, where inflammation of the testis exists, to apply cooling lotions. For chronic orchitis strapping of the testis may be required.

In order *to tap a hydrocele,* the tumour must be firmly grasped in the palm of the left hand, and the skin over its anterior wall purified and made tense. A spot at the antero-inferior margin is then selected, as free from vessels as possible, and a fine sterilized trocar and cannula inserted almost directly upwards, so as to pass in front of the body of the testis (Fig. 571). The site selected for tapping must, of course, vary with the position of the testicle, which should be previously demonstrated. The fluid having been withdrawn, the cannula is removed and the puncture covered with wool and collodion. The condition usually recurs after a longer or shorter period, and the operation may then be repeated. If a dirty instrument is employed, inflammation, and even suppuration, may follow, whilst if a vessel or the body of the testis is punctured, a hæmatocele may result.

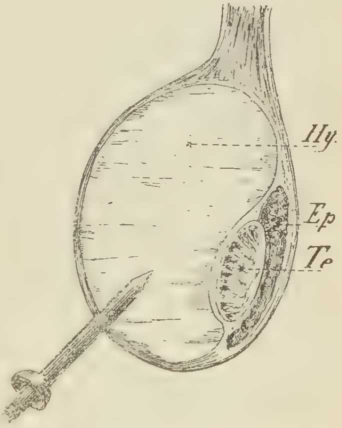

FIG. 571.—METHOD OF TAPPING A HYDROCELE.

Te, Testis; *Ep*, epididymis; *Hy*, hydrocele.

Radical treatment consists in injection of the cavity, or excision of the lining membrane. (i.) *Injection* of the cavity after tapping has long been a favourite method. Many different reagents have been employed, such as port wine, tincture of iodine, solution of corrosive sublimate (1 in 500), or glycerine of carbolic acid. Perhaps the best is the tincture of iodine, but that contained in the British Pharmacopœia is not strong enough, and the old Edinburgh tincture, which is nearly the same strength as the lin. iodi, B.P., should be employed. The amount used varies with the size of the hydrocele, but for one of moderate dimensions it will suffice to inject, after tapping, 2 drachms of the tincture, and after manipulating it well within the cavity, a part, say 1 drachm, is allowed to escape. Smart inflammatory reaction follows, and a cure may result, probably from obliteration of the vaginal space by the formation of adhesions. In a certain percentage of cases failure may be expected, and this is more likely to happen if too weak an irritant has been employed, or if the hydrocele is a chronic one with thick and indurated walls, or has been tapped on several previous occasions. (ii.) The *open method* of operation is now generally adopted, and is particularly recommended in large and chronic cases. The hydrocele is cut down on through an incision in the upper part of the scrotum, and the tunica vaginalis isolated from the superjacent structures. The cavity is opened, and the parietal portion of the tunica snipped away with scissors close to the testicle. A number of vessels will need to be ligatured; a drainage-tube is inserted, and the wound closed in the ordinary way. The results of this practice are most satisfactory.

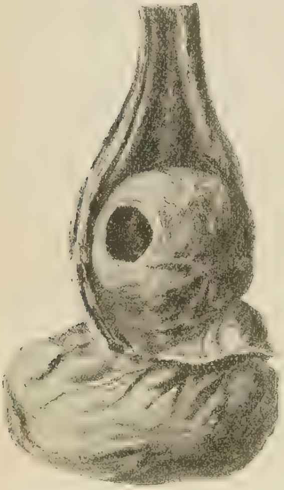

Fig. 572.—Encysted Hydrocele of Epididymis. (College of Surgeons' Museum.)

When the sac is not too large, and the tunica supple and uninfiltrated, it often suffices to turn it inside out, and stitch its edges to the back of the epididymis.

In infants hydrocele is by no means uncommon, and may be, but is not always, of the congenital type. The communication is sometimes very small, so that reduction is impracticable, although on lying up the cavity slowly empties; it is desirable to make certain as to this point before undertaking treatment. If the sac communicates with the peritoneal cavity, it may be treated as a hernia by truss pressure, or more satisfactorily by operation. If no communication exists, many cases get well spontaneously, but as a useful *placebo* the scrotum may be painted over frequently with a lotion of chloride of ammonium (grs. x. ad ℥i. mixed with rectified spirit and water); failing this, acupuncture may be tried, the fluid being allowed to escape into the scrotal tissues; in the few cases in which this fails, an open operation (incision with drainage or partial removal of the sac) will be required.

2. **Encysted Hydrocele** of the testis occurs in two main forms, according to whether it arises in connection with the epididymis or the body of the testis.

(*a*) *Encysted Hydrocele of the Epididymis* exists usually as a rounded globular swelling, tense and elastic in consistency, and translucent. It is situated above the body of the testis, and close to the head of the epididymis (Fig. 572). As a rule, it does not attain a size greater than that of the body of the testis itself, so that it may appear as if a double testicle was present; the hydrocele is, of course, devoid of testicular sensation. Less frequently it may attain considerable dimensions, even projecting below and around the testicle which, though enveloped by it, is quite distinct from it. The fluid contained within these cysts is usually milky and opalescent in appearance, owing to an admixture of semen; under the microscope spermatozoa, either living or dead, can be demonstrated; on account of this it is sometimes termed a *spermatocele*. The specific gravity is lower than that of ordinary hydrocele fluid, and there is but little albumen. The origin of these cysts has given rise to much discussion. They are of a very different nature to the ordinary vaginal hydrocele, or even to the encysted hydrocele of the cord, since the walls are not lined with endothelium, but with cuboidal or columnar epithelium. They are probably due either to a dilatation of one or more of the vasa efferentia testis, or more frequently to distension of some of the fœtal relics always found near the head of the epididymis, especially of those known as Kobelt's tubes; these, as also the vasa efferentia testis, are derived from the tubules of the Wolffian body, differing, however, from them in not becoming attached to the body of the testis (Fig. 72, p. 230). They are thus homologous with the parovarian cysts found in the female. Smaller pedunculated cysts containing clear serum are sometimes met with in this region, arising from a distension of the hydatid of Morgagni, which is developed from the remains of the Müllerian duct.

Treatment is conducted along the same lines as for vaginal hydrocele, viz., by tapping as a palliative measure, and injection or excision in order to establish a radical cure.

(*b*) *Encysted Hydrocele of the Tunica Albuginea* is a condition rarely seen, consisting of a small collection of serous fluid beneath the visceral portion of the tunica vaginalis. It is probably due to dilatation of lymphatic spaces, and has absolutely no clinical significance.

II. **Hydrocele of the Cord** occurs, as already described, in connection with the congenital and infantile varieties of vaginal hydrocele. If limited to the cord, it exists in one of two forms, the encysted or the diffuse.

1. **Encysted Hydrocele of the Cord** arises from imperfect obliteration of the funicular process of peritoneum, the patent portion becoming distended with fluid and giving rise to a cavity lined with endothelium. It is usually detected as a rounded elastic swelling, occupying the inguinal canal, moving freely up and down within it. The upper border is sharply limited, and in favourable cases translucency can be demonstrated. On fixing the testicle the cyst is no longer moveable. The fluid contained within it is identical in nature with that in a vaginal hydrocele. In the female a similar condition arises from imperfect obliteration of the canal of Nuck, giving rise to what is known as a *hydrocele of the round ligament*. **Treatment** consists in removal of the fluid by tapping, or, if a more radical proceeding is necessary, by injection or excision.

2. **Diffuse Hydrocele of the Cord** is but rarely seen. It results from a diffuse œdema of its cellular tissue, and presents on examination a fusiform or sausage-shaped tumour, which extends along the cord for a variable distance.

The term **Chylous Hydrocele** is applied to a distension of the tunica vaginalis with chylous fluid, recognised by being milky in appearance, and under the microscope seen to consist of a fatty emulsion. Several modes of origin have been suggested, but none are very satisfactory. In one case under our care, a series of dilated lymphatics filled with a similar fluid extended upwards from the testicle to the inguinal canal.

Varicocele.—A varicose condition of the pampiniform plexus (Fig. 573) is very commonly met with in young men, but seldom in those of advanced age, except when it has become chronic, or is due to malignant disease of the kidney (p. 1211). It usually occurs in individuals with a lax and pendulous scrotum, and is often associated with masturbation, which induces abnormal vascularity of the testis. The fact that it sometimes develops in quite young boys suggests, however, that there is some congenital condition associated with it. It may also be caused by the pressure of a truss applied for the relief of a hernia. It is almost invariably on the left side, and the reasons given for this are as follows: (*a*) The left testis usually hangs lower than the right, and hence the spermatic veins are longer and exposed to greater blood pressure. (*b*) The left spermatic vein opens into the left renal vein at right angles, and no valve is present at the orifice, whilst that on the right side opens obliquely into the vena cava and is valved. (*c*) The presence of the sigmoid flexure on the left side of the body, and its distension by accumulated fæces as a result of constipation, may lead to pressure on the abdominal portion of the left spermatic vein.

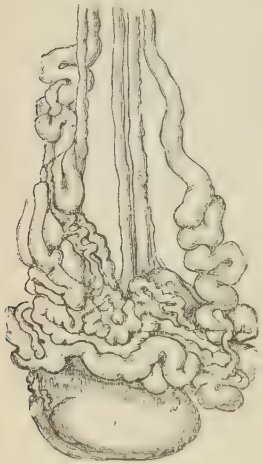

FIG. 573.—VARICOCELE. (TREVES' 'SURGERY.')

A varicocele is characterized by the presence of a soft irregular swelling in the scrotum, which is somewhat pyramidal in shape, the main mass being below and slightly overlapping the testis, and the apex above. It consists of dilated and tortuous veins, the outlines of which can often be seen through the skin (Fig. 574). They impart a sensation to the finger which has been likened to a collection of worms in a bag; there is a distinct impulse down the veins on coughing. On assuming the recumbent posture the swelling almost disappears, owing to the vessels being emptied of their contained blood; if pressure is subsequently applied over the external abdominal ring, and the patient allowed to stand, the tumour reappears, filling from below upwards. A sensation of weight and pain usually accompanies a varicocele, whilst severe neuralgia of the testis may be induced. It is a frequent source of seminal emissions, and may result in testicular atrophy. Phlebitis is liable to follow an injury, and may lead to a spontaneous cure; if one of the dilated veins is ruptured, severe hæmorrhage ensues, causing a diffuse hæmatocele of the cord. In favourable cases the condition disappears spontaneously.

The **Diagnosis** of varicocele is easily made, the only condition for which it is likely to be mistaken being an omental hernia; the difference between the two conditions has been discussed at p. 1095.

The **Treatment** of slight cases of varicocele consists in supporting the testicle and scrotum by means of a well-fitting suspender, whilst

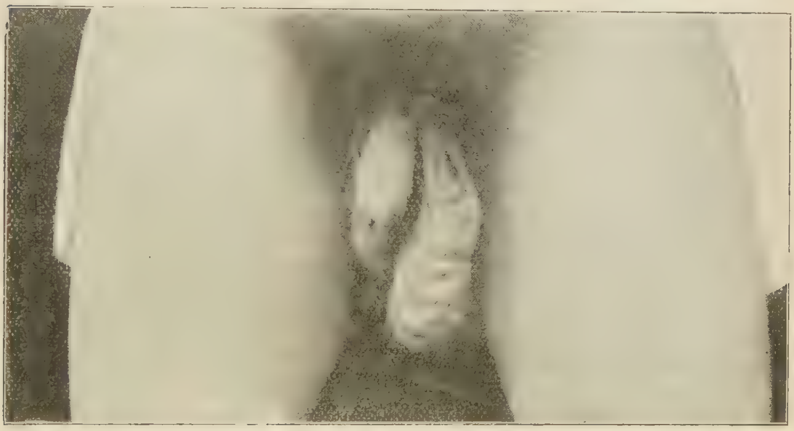

FIG. 574.—LARGE VARICOCELE IN A PATIENT AGED 35 YEARS, WHO HAD USED NO SUPPORT FOR MANY YEARS.

the patient is also instructed to bathe the parts with cold water night and morning, and to take such measures as shall ensure a daily action of the bowels.

Radical Treatment by excision of the veins is advisable in neuralgic cases, where atrophy of the testis is threatening, or in order to fit the patient for admission into any of the public services. The operation is conducted as follows: The pubic region having been shaved and purified, an incision $1\frac{1}{2}$ inches long is made in the direction of the cord, with its centre a little below the external abdominal ring. The structures of the cord are raised on the fingers, and the coverings divided, so as to expose the spermatic veins at their upper end. Two main branches are usually found in this situation, but occasionally there is only one. These are cleaned and carefully isolated from the other structures of the cord, and a ligature is applied to them at the external abdominal ring. The vessels are now clamped with a pair of Spencer Wells forceps below the ligature, and divided between it and the forceps. The lower end, grasped by the forceps, is stripped downwards, so as to free the pampiniform plexus from the other elements of the cord, and the dissection can be carried nearly as far as the epididymis by drawing the testicle up into the wound. The lower end of the veins is ligatured in one or two portions and divided. By this means the whole varicocele is removed. If the scrotum is pendulous, and the testicle hangs low, it may be advisable to raise it by tying the upper and lower ligatures together, care being taken not to pull them off in so doing; perhaps it is wiser to introduce a suture through the divided ends of the veins above and below, which are purposely left long. The wound is then closed without a drainage-tube, and dressed as usual. The patient is kept in the recumbent posture for a fortnight, until organization has occurred in the divided ends of the veins, and a firm cicatrix has formed. This method of treatment is infinitely superior to that often practised of exposing the veins in the scrotum, since a wound in the groin always heals much more readily than one in the scrotum; whilst it is easier to dissect the veins out from above, where only one or two trunks exist. The venous return after the operation is maintained by the vein or veins running with the artery to the vas in the posterior portion of the cord. Occasionally, if the removal of veins has been too complete, a hydrocele develops subsequently, owing to the passive congestion of the testis. It is usually unnecessary to remove any scrotal integument, although it is often redundant; but after the wound is soundly healed, the dartos may be stimulated daily by brushing the scrotum with a clothes-brush.

Neuralgia of the Testis is characterized by the organ becoming exquisitely tender and painful, although apparently healthy. It usually occurs in young adults of nervous temperament, or in middle-aged gouty men. It is not uncommonly associated with a varicocele. The pain is usually paroxysmal in character, and very intractable. **Treatment** must be directed mainly to the general health, consisting in the administration of nerve tonics, such as iron and quinine, whilst locally sedatives, *e.g.*, belladonna and aconite, may be applied. It is also advisable that a suspender should be worn.

Atrophy of the Testis results from several causes: (i.) It may be due to a congenital arrest of development, as met with in displacement or late descent. (ii.) It is most frequently the consequence of inflammatory affections, either of the body or epididymis, owing to the cicatricial contraction caused thereby leading to compression of the vessels. It occasionally follows the metastatic orchitis of mumps, especially in adults, whilst it is also due to syphilitic disease. (iii.) It arises from impaired nutrition, as after the division of the supplying arteries in operations for varicocele or hernia, or from compression of the cord by closing the inguinal canal too firmly in the operation for the radical cure of hernia. It appears, however, that division of the spermatic vessels alone will not suffice to determine atrophy, if the artery to the vas with its accompanying veins and nerves are preserved intact. (iv.) Chronic congestion of the organ, as by a varicocele, may induce atrophy; whilst (v.) sexual excesses are also stated to lead to it. If unilateral, it is of comparatively little importance; but where both organs are affected, sterility is sure to result, and the patient, if previously young and healthy, is likely to become depressed in spirits and melancholic. This may be due in part to mental causes, but also in measure to the absence of seminal secretion, the re-absorption of which into the system is, according to Brown-Séquard, an important factor in the maintenance of a vigorous state of mind and body.

General Diagnosis of Scrotal Tumours.

When a patient presents himself for examination with a swelling in the scrotum, the surgeon has to decide whether it is a hernia, a hydrocele, a hæmatocele, a varicocele, or a solid enlargement of the testis, and, if the latter, of what nature. The first point to which attention is directed is the condition of the cord immediately below the external ring. If this is of normal size and consistency, hernia and diffuse hydrocele of the cord are thereby excluded, whilst the existence of a rounded tense swelling, moveable within the canal, but becoming fixed on holding the testis, indicates that an encysted hydrocele of the cord is probably present. When, however, the cord is more or less masked, further examination speedily determines whether a hernia or a diffuse hydrocele or hæmatocele of the cord exists, since the former is often reducible, has an impulse on coughing, and is rounded or nodular in outline, and the latter are sausage-shaped, always irreducible, and semi-fluctuating.

When the swelling is purely scrotal, inspection and manipulation will at once decide if it is a varicocele, by its characteristic feel, by its disappearance on assuming the recumbent posture, and filling again from below on standing up. If the swelling is rounded in outline, the next point to be determined is whether it is solid or fluid. If fluid, it is probably a hydrocele, or the early stage of a hæmatocele; the translucency of the former, and the sudden appearance and non-translucency of the latter, should suffice to demonstrate its nature. It is possible that the hydrocele is merely a secondary complication, and hence no final opinion should be given until it has been tapped, and the condition of the body of the testis investigated. If however, a solid mass exists in the scrotum, it is either a hæmatocele in its later stages, or some form of sarcocele, whether simple, syphilitic, tuberculous, or neoplastic. A *hæmatocele* is possibly recognised by its history, and by there being a fluid centre to the swelling, surrounded by solidified tissue. *Chronic orchitis* and *syphilitic* enlargement of the testis are so much alike as to render diagnosis always uncertain in the absence of a distinct syphilitic history; but if the swelling is extremely hard, with a smooth and regular outline, without testicular sensation, limited to the body of the testis, and accompanied by a hydrocele, it is probably syphilitic. *Tuberculous* disease, on the other hand, occurs more frequently in younger individuals than does the syphilitic variety, whilst the epididymis is usually first attacked, becoming nodulated, the cord is early implicated, hydrocele is rare, suppuration is frequent, and testicular sensation remains till the body of the testis is disorganized. *Tumours* always impart a distinct sense of weight to the hand, quite different to that noticed in tuberculous or syphilitic disease; if a simple tumour is present, it is rounded, slow in growth, and the cord is unaffected. Malignant disease is characterized by rapid growth, more severe pain, and early implication of the structures of the cord and of the lumbar lymphatic glands. The enlargement of both testes is in favour of tubercle or syphilis rather than of malignant disease. A certain small number of cases will remain where, in spite of every care, the nature of the mass is still a matter of doubt; in such the diagnosis cannot be established without puncture or an exploratory incision.

Whilst weighing carefully the local conditions, we must not omit thoroughly to investigate and appreciate the general history and condition of the patient, his age, appearance, previous habits and illnesses, etc. At the same time, an examination of the internal organs should be made to ascertain, as far as possible, the existence or not of concurrent disease—*e.g.*, tuberculous disease of the lungs or kidneys, or secondary malignant deposits.

Castration is required for many different conditions, which have been already described—*e.g.*, for malposition, tuberculous disease, old-standing hæmatoceles, and simple or malignant tumours. The operation is conducted as follows: The pubes and perineum having been previously shaved and purified, the surgeon, standing on the same side of the patient as the organ to be removed, makes an incision down to the testis. If large and adherent to the scrotal tissues, the incision must necessarily involve the scrotum, but wherever practicable it is wise to avoid the scrotal integuments, making the incision over the cord. It should always extend upwards as far as the external abdominal ring, so as to enable the structures of the cord to be divided high up—a most important matter in tuberculous and malignant disease; the inguinal canal can then also be closed, if necessary. The testis or tumour is enucleated from its surroundings, and the cord isolated and divided as high as possible, after transfixing and securely ligaturing it with silk. Some surgeons prefer to separate the tissues of the cord, and to take them up individually, but this is a matter of little importance. The stump should not be allowed to slip back into the canal until all bleeding has completely stopped, and it has been suggested that the cut end of the vas should be touched with pure carbolic acid as a precautionary measure. All bleeding points in the scrotum are now secured by ligature, and these may be numerous; the wound is closed by sutures, a drainage-tube being inserted in the scrotum, and by choice coming to the surface at the upper end of the wound -that is, as far from the perineum as possible.

In the performance of double castration, it is recommended to make two crescentic incisions from side to side, so as to include between them a portion of the scrotal integument, in order to reduce the subsequent redundancy of unnecessary tissue.

Affections of the Vesiculæ Seminales.

Acute Vesiculitis is not often met with, but sometimes arises, in association with prostatitis, as a complication of gonorrhœa. It is characterized by deep-seated pain in the perineum, together with irritability of the neck of the bladder and increased frequency of micturition. Defæcation becomes painful, and on examination of the rectum the vesiculæ can be felt enlarged and tender. If suppuration ensues, an abscess forms, which usually bursts into the rectum, but sometimes into the bladder or peritoneal cavity. As a rule, the condition disappears *pari passu* with the gonorrhœa; but when suppuration has supervened, it is advisable to open the abscess by a deep incision through the perineum, guided by a finger in the rectum.

Subacute or **Chronic Vesiculitis** is not uncommon, the latter condition being often associated with prostatitis, and one of the most frequent causes of gleet. Seminal emissions and priapism may be caused by it, and the enlarged organ can be felt through the rectum. A good deal of pain, often referred to the back, is experienced. The treatment is the same as for chronic prostatitis.

Tuberculous Disease attacks the vesiculæ seminales as a result of extension from the testis along the vas, being almost always associated with similar disease of the prostate and base of the bladder. The organs can be felt enlarged, and if suppuration occurs, the abscess may burst into the rectum or bladder, or possibly into both, a recto-vesical fistula being thereby developed. It is possible to reach the vesiculæ through a semilunar incision in the perineum, displacing the rectum backwards, and the bladder and prostate forwards, or from behind by removing the coccyx and part of the sacrum, as in Kraske's operation. When exposed, complete excision is sometimes possible, or an opening is made into them, and the cheesy contents scooped out.

Affections of the Scrotum.

Injuries of the Scrotum.—Contusions and blows give rise to ecchymosis, which may be so extensive as to warrant the term *hæmatoma scroti* which has been applied to it.

Incised wounds may affect the skin and subcutaneous tissues, or may lay open the tunica vaginalis, with or without protrusion of the testicle. All that is needed in such cases is to render the wound aseptic, and to deal with it on general principles. Considerable destruction of scrotal tissue may be repaired by transplantation of flaps from the inguinal region, or by grafting according to Thiersch's method.

Cellulitis of the Scrotum most commonly results from extravasation of urine, for which see p. 1268. It may occasionally arise from other causes, and leads to great constitutional disturbance, usually of an asthenic type, and often to considerable sloughing; the testes may be exposed when the sloughs come away, or may even be involved in the same process. As a general rule repair is very active in the scrotum.

Œdema of the Scrotum is usually due to dropsy, being often associated with general anasarca and ascites. It may attain considerable dimensions. *Acute inflammatory œdema* of the scrotum is a term sometimes applied to erysipelas affecting this region, on account of the absence of the vivid red colour usually caused by that affection. Considerable œdema is always present, and gangrene of the skin may result. As soon as the gangrene becomes limited, it should be excised, and the margins of the wound brought together by sutures, or allowed to heal by granulation.

Scrotal Fistulæ are usually due to the bursting of abscesses in connection with the urethra (see Perineal Abscess).

Sinuses of the Scrotum are often found in connection with tuberculous or syphilitic disease of the testicle.

Eczema of the Scrotum is a troublesome affection, giving rise to great pruritus and irritation. It results from the presence of pediculi, but the more chronic forms occur amongst workers in tar and paraffin, and also in chimney-sweeps, being due to the constant irritation of the corrugated scrotal integument by dirty clothes. It is characterized by the presence of warty outgrowths, and not unfrequently runs on to **epithelioma,** originating the condition known as *chimney-sweep's* or *paraffin cancer*. The usual characteristics of such a new growth are present, and in some of the deeper cells particles of soot have been demonstrated. The inguinal glands are usually involved, but not till late, and the progress of the case is slow. The only treatment which can be adopted is complete removal, together with the inguinal glands.

For **Elephantiasis Scroti,** see p. 362.

CHAPTER XLIII.

SURGERY OF THE FEMALE GENITAL ORGANS.*

Affections of the Vulva.—Injuries to the External Genitalia may arise from direct violence, or during parturition from the forcible expulsion of the head. In the non-pregnant condition the results differ but little from other similar lesions, and require no special treatment or consideration. Occasionally a kick or a fall on a stick or paling may result in *laceration of the recto-vaginal septum.* The wound is usually contused, and the margins irregular, so that immediate suture is unlikely to succeed. The parts are therefore kept clean by frequent douches and allowed to granulate, and the loss of substance is in that way often made good; should a fistula persist, a plastic operation will be subsequently necessary. Of course, if the original injury is a clean incision, immediate operation to close the defect is desirable.

In the pregnant state or when large varicose veins are present, an injury to the vulva may result in serious hæmorrhage if there is an external wound, or in the formation of a large *hæmatoma.* The labium becomes much swollen and firm to the touch, owing to the coagulation of the blood; suppuration often follows, especially if the injury is associated with a superficial abrasion. **Treatment.**—If the hæmatoma should hinder parturition, it may be necessary to incise it at once and turn out the blood-clot. Under other circumstances it may be treated by the application of cooling lotions; but should it persist or if suppuration ensues, operation will be required; the cavity is opened, emptied and packed with gauze to ensure healing by granulation.

Varix of the vulva is not unfrequently associated with a similar condition in the legs, or may sometimes arise as a result of blocking of the external iliac vein, owing to the opening up of collateral branches. One or two veins may become enlarged, often running transversely across the Mons Veneris, or large bunches of veins may form in the labia. Pregnancy usually aggravates this condition to an alarming degree, and a very slight injury may determine a rupture of the veins. **Treatment.**—If troublesome and causing much pruritus or irritation, the veins may be excised under careful antiseptic precautions.

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* It is impossible in a work of this size to include more than a comparatively brief notice of the more important gynæcological conditions which encroach on the domain of the general surgeon. As a means of distinction we have considered that all vaginal operations, etc., are purely gynæcological, whilst those necessitating abdominal section belong as much to the general surgeon as to the gynæcologist. Vulval lesions, of course, may come under the care of either,

Vulvitis, or inflammation of the lining membrane of the vestibule, is due to uncleanliness, gonorrhœa, or to irritating discharges coming from above. It is characterized by injection of the mucous membrane, by itching or smarting pain, especially on walking, and a secretion of mucus or muco-pus, causing the labia to stick together. The mucous follicles may become affected, and a localized abscess result, situated either immediately beneath the mucous membrane or in the substance of the labium. The *treatment* consists in the use of warm and mild astringent or antiseptic lotions to purify the part (*e.g.*, lotio plumbi), sitting in hot water being most beneficial. At the same time the patient is kept quiet, and the bowels are opened by a saline purge. When a follicular abscess forms, it should be incised through the mucous membrane and its cavity stuffed with a small portion of dressing. A labial abscess should be freely opened at any spot where it is threatening to point, and the cavity packed with gauze to ensure healing from the bottom.

Vaginitis may be secondary to vulvitis, or associated with an inflammatory affection of the uterus. As a primary lesion it is most commonly due to injury, such as the injection of too hot water, or the presence of a foreign body—*e.g.*, a badly-fitting and retained pessary, or awkward or violent coitus. Vaginitis is not generally a marked feature in gonorrhœa. The symptoms are a sense of heat and pain, frequent and painful micturition, and a free muco-purulent leucorrhœa. Complications may arise from extension upwards to the uterus and tubes. **Treatment** consists in warm soothing injections in acute cases, together with hot hip-baths; in the more chronic types astringent injections are required.

Cysts of the Labia are occasionally seen, being due to the blocking of the duct of a mucous follicle, or of the more specialized vulvo-vaginal glands (glands of Bartholin); they may attain considerable dimensions, and must be freely dissected out if causing any inconvenience.

Various other tumours of the vulva occur—*e.g.*, elephantiasis epithelioma, etc., but have no special peculiarities.

Affections of the Round Ligament are not very uncommon. Non-obliteration of the canal of Nuck leads to the appearance of a *congenital inguinal hernia*, which is very frequent in girls and young unmarried women. In the operation required for its cure the round ligament is included in the ligature which encircles the neck of the sac. A *hydrocele* of the round ligament is due to a partial obliteration of the same structure, the patent portion becoming distended with a serous exudation. It presents as a tense, rounded swelling just below the external abdominal ring or in the inguinal canal, and is treated by dissecting it away. Occasionally cases of bilocular hydrocele are met with, in which an external cavity communicates with a large pelvic collection of fluid enclosed in a serous membrane. *Tumours* of the round ligament are unusual, but occur in the form of lymphangioma and fibro-myoma. An interesting instance of the latter was seen in a woman who was also the subject of uterine fibro-myomata necessitating hysterectomy. The tumour of the round ligament was as large as an orange.

Uterine Displacements.—The maintenance of the uterus in its normal position of slight anteversion is due to the associated influence of many diverse factors. Displacements are caused by many lapses from the normal condition—*e.g.*, lack of support, as by rupture of the perineum, increased pressure from above, increased weight of the uterus, as from subinvolution after pregnancy, chronic inflammation or the presence of tumours, the traction of adhesions resulting from pelvic cellulitis, etc. The most common displacements are forwards, constituting anteversion or anteflexion; backwards, in the form of retroversion or retroflexion; and downwards, giving rise to prolapse or procidentia.

It is unnecessary to enter into the symptoms and ordinary treatment of these conditions; but the operative treatment of them requires notice.

Anterior displacements require no external operative treatment.

Posterior displacements are not unfrequently dealt with by operations through the anterior abdominal wall. Two chief methods are employed—viz., shortening the round ligaments and hysteropexy. *Shortening of the round ligaments* can be undertaken as an extra- or as an intra-peritoneal procedure. (i.) Alexander's operation is extraperitoneal, and suitable only for uncomplicated cases. The inguinal canal on each side is exposed and the external oblique slit up; the round ligament is identified, isolated, drawn taut, and the slack portion cut away; the posterior end is then fixed in the canal by sutures, which also serve to close it; the external oblique is also carefully sutured. (ii.) In the intra-abdominal operation a complete investigation of the pelvic viscera is possible. A small median incision is made; the round ligament on either side is isolated, doubled over, and stitched to itself so as to remove all slackness. This latter operation is probably much the more satisfactory of the two. Of course, the additional use of a suitable pessary may be desirable.

A still more satisfactory measure consists in detaching the slack round ligament from its connections, and drawing it on either side through a small incision about 2 centimetres from the middle line through the peritoneum and rectus muscle, including its anterior sheath. The two loops are then sutured together across the middle line in front of the line of union of the two muscular segments of the abdominal wall. A few stitches are inserted to prevent the ligaments from retracting. The uterus is thus fixed forwards in a normal position and condition.

Hysteropexy (*ventro-fixation*), or the fixation of the uterus to the anterior abdominal wall, is a procedure that must be cautiously undertaken in married patients who have not reached the climacteric. An incision 2 or 3 inches in length is made immediately above the symphysis, and the fundus uteri is drawn forwards by a volsellum. Three silkworm gut stitches are inserted through the abdominal parietes and peritoneum, and also through the body of the uterus just posterior to its axis. The stitches should include about $\frac{3}{4}$ inch of the uterine wall in their grasp, and go about $\frac{1}{8}$ inch deep. On drawing them tight, the uterus is fixed forwards against the abdominal wall and contracts adhesions. In some cases it may be desirable to scarify the uterine wall before tying the stitches, so as the better to determine adhesions. As a general rule the adhesions stretch somewhat, and hence allow a certain degree of play, but without the likelihood of a return of the displacement.

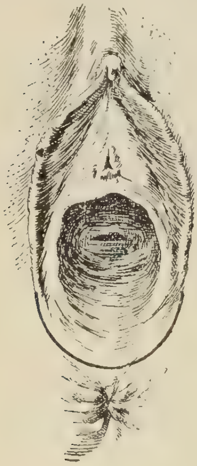

FIG. 575.

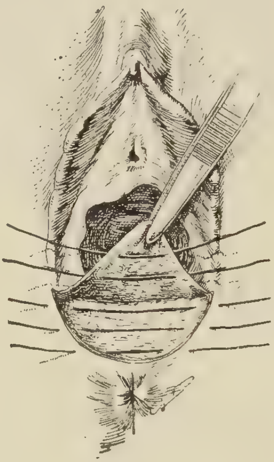

FIG. 576.

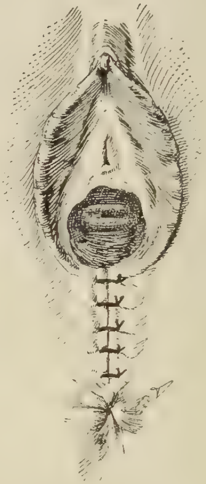

FIG. 577.

FIG. 575.—INCISION FOR REPAIRING RUPTURED PERINEUM.
FIG. 576.—VAGINAL FLAP DISSECTED UP FROM RECTO-VAGINAL SEPTUM AND DRAWN FORWARDS. (Some of the sutures are introduced.)
FIG. 577.—OPERATION FOR REPAIRING A RUPTURED PERINEUM COMPLETED.

Prolapse of the Uterus is most commonly associated with a ruptured perineum and chronic metritis. The anterior vaginal wall often gives way first and brings down the bladder, causing considerable dysuria or vesical irritability; and then the uterus itself descends, and may even protrude from the vulva, the vagina being turned inside out, and its walls becoming dry like skin, and perhaps ulcerated from persistent irritation. **Treatment** varies according to the condition present and with the causes. The uterus, if enlarged and inflamed, may need to be curetted so as to diminish its bulk and weight. The perineum, if defective, must be repaired by one of the many forms of perineoplasty now in vogue. Possibly the introduction of a suitable pessary may suffice to keep the uterus in place for a sufficient time to allow the uterine supports to regain their tone. In some cases hysteropexy will be indicated, but in the worst forms vaginal hysterectomy, combined with some operation to diminish the size of the vaginal canal, may be required.

The operation for *repairing a ruptured perineum* necessarily varies with the extent and completeness of the tear. Obstetricians should always endeavour to stitch up these ruptures immediately after labour, as the parts are then very insensitive, owing to the stretching which they have suffered, and patients are very loth to undergo a secondary operation soon after. The plan usually adopted for remedying a defect which does not quite extend to the anus is indicated in Figs. 575-577. An incision is made skirting the posterior vulval margin, and extending forwards on either side to the terminations of the nymphæ. By deepening this the posterior vaginal wall can be separated from the rectum, great care being taken not to encroach on either cavity, and the flap thus produced is drawn forwards. The wound is then stitched up transversely, and an effective perineal body produced. A more extensive intravaginal operation is needed when the rent involves the anal orifice.

Uterine Tumours.

Fibro-myomata are by no means uncommon, developing during sexual activity, and causing symptoms partly from their location in the uterus, partly from the size which they may attain. Any part of the uterus may be affected primarily, but they generally originate in the substance of the wall, and that usually the posterior wall; if they remain in this relation, they are known as *interstitial* or *intramural* fibroids (Fig. 578, 1). When they are situated near the inner or outer uterine wall they may project either into the uterine or peritoneal cavities, constituting the *submucous* (2) or *subserous* (3) fibroids. Occasionally they become pedunculated, and then a *fibroid polypus* of the uterus may develop, and project through the os into the vagina, where it may undergo strangulation or torsion, and may slough away or become acutely inflamed. A pedunculated subserous fibroid may similarly become twisted or inflamed, and then may either slough, or may gain adhesions elsewhere—*e.g.*, to the omentum, and finally become separated from the uterus.

The *actual structure* of these tumours varies slightly, but they are all more or less of a fibro-myomatous nature—*i.e.*, they consist of muscle fibres similar to those of the uterus, with a varying amount of fibrous stroma and bloodvessels. Occasionally they are very hard and not specially vascular; in other cases they are softer and more vascular, and then usually grow more quickly. They are surrounded by a capsule of varying density, which is often the seat of many enlarged veins, and if these are ulcerated into, considerable hæmorrhage follows. The uterus generally becomes hyperæmic and enlarged, and the mucous membrane thickened; not unfrequently endometritis is present, and the inflammation may spread up to the tubes, causing pyosalpinx.

Various secondary changes may occur in uterine fibroids. They may become *œdematous*, or undergo *cystic* degeneration, as a result of defective nutrition, and that generally in young people; fibrocystic disease of the uterus is thereby determined. Occasionally in old women, where the evolution of the growth has long ceased, *calcareous degeneration* occurs, and the growth is converted into a stony mass. In younger women a somewhat similar change may be present, and the fibroid becomes hard, but not stony. The existence of this condition must be remembered in connection with the radiographic examination of the pelvis, as circular shadows of a perplexing nature m .y be produced by these tumours. *Inflammation and pyogenic infection*, with perhaps abscess formation, may follow abrasion of the mucous membrane with a sound, and *sloughing* of the growth may result either from an inflammatory attack or from defective blood-supply. It is possible that *sarcoma* may supervene in some few cases, but the association is not yet absolutely proven.

The **Symptoms** vary much in different cases, but are mainly those of hæmorrhage and pressure. *Hæmorrhage* occurs either as a prolongation of the normal menstrual periods (menorrhagia), or as a chronic and persistent effusion of blood (metrorrhagia). It may be absent in subserous and interstitial fibroids, and is most marked in the submucous variety, in which the endometrium is congested and succulent. The amount of blood lost may drain the patient, who looks anæmic and dehydrated. There may be but little *pain* in the subserous variety, unless the growth becomes twisted or impacted in the pelvis. When the tumour projects upwards into the abdomen nothing but a sense of weight is experienced unless the size is so great as to encroach seriously on the viscera. When the growth is mainly pelvic, and especially when a fibroid of the cervix extends sideways into the broad ligament, or when impaction occurs, the symptoms may be extremely distressing. Vesical irritability may be marked, and micturition may be painful and difficult. Tenesmus or constipation may arise from pressure on the rectum; hydrone-

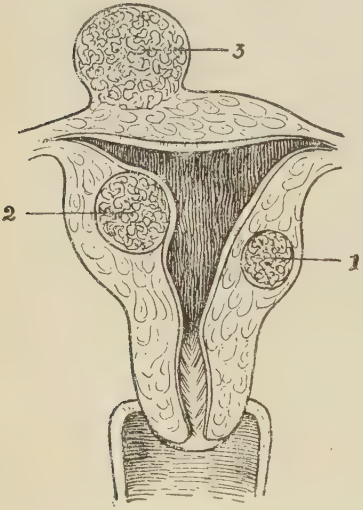

FIG. 578.—DIAGRAM OF UTERUS WITH FIBRO-MYOMATA.

1, Interstitial fibroid; 2, submucous fibroid; 3, subserous fibroid.

phrosis, when the ureters are compressed; and severe neuralgic pain down the leg, should the pelvic nerves be encroached on. The presence of a polypoid submucous growth is likely to cause violent expulsive contraction of the uterus.

The **Diagnosis** is made by palpation, digital examination, and the use of the sound. Bimanual examination should reveal the size and shape of the uterus, and much useful information can often be obtained by a combined vaginal and rectal examination. The sound will demonstrate the increased length of the uterine canal, which is often in addition twisted.

The **Prognosis** has to be considered carefully in every case before determining for or against operative treatment. The majority of the cases improve at the menopause, the growth shrinking and the hæmorrhage ceasing; exceptions to this rule are, however, not unknown. It is therefore obvious that if the patient is approaching the climacteric and the symptoms are not grave, it may be advisable to wait for that event. On the other hand, if the condition occurs in a young woman, and especially if the hæmorrhage is sufficiently severe to necessitate prolonged rest and more or less chronic invalidism, operation is certainly desirable. Of course, the existence of severe hæmorrhage, or of symptoms of pelvic pressure, would at all ages justify operation.

Treatment.—If the symptoms are not such as to warrant operation, all that is required is that the patient should rest at the menstrual periods, and that ergot and iron should be administered if necessary.

Operative Treatment consists in either the enucleation of the tumour or the extirpation of the uterus, and the removal of the ovaries and tubes.

(1) **Myomectomy,** or the enucleation and removal of the tumour apart from the uterus, is only suitable under special circumstances. When the growth projects into the uterus or vagina as a polypus, the vaginal route may be adopted; the cervix is dilated if need be, and after incising the mucous membrane the growth can be enucleated by the finger. A subserous fibro-myoma can similarly be removed without difficulty if it be thought desirable. Not unfrequently this condition is met with in laparotomies for other conditions, and the surgeon may think it desirable to remove the growth. A longitudinal incision down to the capsule and a sweep round of the finger usually suffices to enucleate the tumour, and that with very little bleeding. Two or three deep stitches may be introduced into the uterine substance, and the peritoneum adjusted and apposed by superficial stitches. No drainage is required as a rule.

(2) **Abdominal Hysterectomy** for fibroids is a most successful procedure. It may suffice to remove the organ through or above the cervix (supra-vaginal hysterectomy), or it may be needful to include the cervix in the mass that is removed (pan-hysterectomy). The procedure is identical up to a certain point, but the latter operation is rather the longer, and the dangers are a little greater.

The patient must be carefully prepared as for any other abdominal operation (p. 959), but in addition the pubes and vulva must be shaved and thoroughly purified; the vagina should be douched for some days previously, and an antiseptic dressing worn, and if need be the uterine canal should be curetted and disinfected with some powerful antiseptic.

After anæsthesia has been induced, the Trendelenburg position is adopted, and an incision of suitable length made in the median line. The parts are then carefully explored, and if no adhesions exist, an abdominal cloth is packed in over the intestines in order to protect and keep them from exposure and injury. If adhesions to omentum or gut are present, they must be carefully divided; it is, of course, most desirable that a complete peritoneal covering should be secured for any adherent organs; omental grafts may be sometimes useful in this direction. The uterus is now lifted up and drawn into the incision by a Doyen's myoma screw or a stout volsellum.

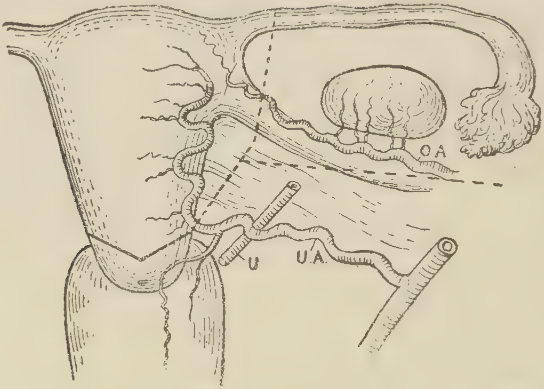

Fig. 579.—Diagram of Uterus, Vagina, and Broad Ligament, seen from in Front.

O.A., Ovarian artery; U.A., uterine artery; U., ureter. The dotted lines represent the division of the broad ligament in hysterectomy according to whether or not the ovary is removed. The continuous dark lines crossing the uterus indicate the incisions through the uterine substance in supravaginal hysterectomy.

The broad ligaments are then examined, and a decision made as to whether or not the ovaries and tubes are to be saved. It is certainly desirable that in a young woman an effort should be made to retain at any rate one ovary, thereby avoiding the nervous symptoms often determined by an acute artificial menopause. The lines of section of the broad ligament under these two conditions are indicated diagrammatically in Fig. 579.

A pedicle needle carrying a sufficient length of well-boiled silk is carried through the round ligament so as to secure the ovarian artery and veins, and tied as far away from the uterus as possible; a broad ligament clamp may then be placed in position close to the uterus, so as to prevent venous regurgitation, and the broad ligament is divided half-way down. It is often possible and desirable to pick up the divided end of the ovarian artery on the face of this section and secure it separately, whilst the little artery which accompanies the round ligament should also be carefully secured. The ovarian artery on the other side is next dealt with in a similar fashion. A transverse cut is now made across the front of the uterus, involving merely the serous membrane, and connecting the two ends of the incisions in the broad ligaments; the peritoneum below this transverse cut is detached, together with the bladder, from the cervix, and the intra-ligamentary space is thereby opened up on either side. In this will be found the uterine vessels, and it may be possible to see and isolate the uterine artery before securing it by ligature. Care must be taken in this part of the operation to keep close to the uterus, as the ureter comes forwards from behind under the uterine artery to reach the bladder, lying about the level of the os internum. The uterine vessels are in this way carefully secured and divided.

The uterus is now merely held by the connection between the vagina and cervix, and the peritoneal reflection in Douglas's pouch. If a supra-vaginal operation will suffice, the surgeon cuts across the neck of the uterus in such a way as to fashion two flaps, and finally the peritoneum behind is also divided. A few small vessels will probably need to be secured on the face of the uterine stump. This having been effected, the uterine flaps are stitched carefully together so as to bury the open cervical canal; the uterine stump is then covered in by uniting the divided portions of peritoneum. This line of sutures is carried up on either side so as to secure the two layers of the broad ligament; the final result is that the pelvic floor is covered in by a continuous layer of peritoneum, showing a sutured incision which runs transversely from one side to the other. The usual peritoneal toilette follows, and the abdomen is generally closed entirely, no drainage being required.

When the fibroid tumours involve the cervix, it may be necessary to perform pan-hysterectomy. The operation follows along the lines indicated above, up to the securing of the uterine vessels. It is then advisable to open into the posterior vaginal cul-de-sac, and enucleate the cervix from its surroundings from behind forwards, keeping very near to the uterus at the sides so as to avoid the ureters, and keeping clear of the bladder in front. Several vessels derived from the vaginal arteries will require to be secured in this proceeding. The wound in the pelvic floor is closed much in the same way as before, but not so completely as regards the vaginal walls, a small lamp-wick drain of iodoform gauze being introduced between them. The peritoneum is sutured continuously over the gauze, and up on either side to the upper extremity of the broad ligament.

In both cases a pad of antiseptic dressing is maintained over the vulva for a time, and in pan-hysterectomy it is advisable to douche the vagina daily. The gauze packing is removed on the third day, and another strip introduced. The results of this operation are most satisfactory, and the death-rate comparatively small.

(3) **Double Salpingo-oöphorectomy** (removal of ovaries and tubes) was at one time much practised in the treatment of uterine fibroids, and certainly had the effect of checking hæmorrhage and diminishing their growth by determining an artificial menopause. At the same time, the patient is not relieved of the incubus of the growth, and hence the operation is now but seldom employed, except as part of a complete hysterectomy.

Sarcoma of the Uterus is not of very common occurrence. It may be a secondary development following on fibro-myomata, or may be primary. In most cases it occurs as a solid, firm tumour, consisting of spindle cells, but more vascular than and not quite so hard as the majority of fibroids; in others it is of a softer consistency, and may be associated with myxomatous development. It almost always involves the body of the organ, the cervix being unaffected; and it may either attack the mucous membrane primarily as a diffuse infiltration, or constitute a more localized growth in the muscular tissue. Secondary deposits occur in the vagina and elsewhere, and the case runs a more rapid course than a simple fibroid, although the symptoms are much of the same type. There is, however, more discharge from the vagina, which may contain débris of the growth, and becomes somewhat offensive. **Treatment** consists in pan-hysterectomy.

Carcinoma of the Uterus is the most common form of cancer in the female, accounting for over 30 per cent. of the deaths from this disease. It follows the usual rule as to age, being uncommon under thirty years, and most frequently seen between the ages of forty and fifty. It generally occurs in multiparæ, and is probably associated with lacerations of the cervix and inflammatory erosions dependent thereon. The site of origin is usually the cervix, the body being comparatively seldom affected primarily.

Cancer of the cervix starts (i.) as a nodular overgrowth of the glands embedded in its substance; (ii.) as an epithelioma of the vaginal portion, projecting into that passage as a malignant papilloma; or (iii.) as a diffuse affection of the cervical epithelium and its glands, and hence is most frequently of a columnar-celled type. In all these cervical forms the vagina is early affected; the disease spreads more slowly up towards the body of the uterus. The arrangement of vessels and lymphatics will explain the fact that invasion of the broad ligaments is early; these structures become infiltrated and rigid, fixing the uterus, and pressure phenomena upon the rectum, bladder, or pelvic vessels and nerves, will sooner or later be manifested. Destructive ulceration follows, and the bladder or rectum may be laid open, and empty their contents into the vagina, which in the worst cases becomes an evil-smelling cloaca. Adhesive inflammation serves to protect the peritoneal cavity, which is not often opened up.

Carcinoma of the body of the uterus starts in the mucous membrane and its glands, and is rapidly disseminated, infiltrating the whole cavity; it also is of a columnar-celled type. The whole organ may become hollowed out by ulceration, constituting a sloughing cavity from which an abundant hæmorrhagic discharge escapes.

In all cases lymphatic dissemination follows, involving the pelvic glands first, and later on the iliac, and possibly even the inguinal. Compression of the ureters may cause hydronephrosis; the iliac vessels may be compressed and lead to œdema of the legs, and pulmonary embolus secondary to venous thrombosis has been known to cause death. General dissemination to the viscera is not common.

The chief **Symptoms** of uterine cancer are pain, hæmorrhage, and an offensive discharge. Pain is unfortunately not an early manifestation in most cases, and hence the disease has often gained a good hold before the patient comes under observation. As soon as the body of the organ is attacked, or the extra-uterine cellular tissue, it begins to trouble the patient; it is of an aching, gnawing, or boring character, and in the later stages may be so appalling in its severity as to necessitate the injection of huge doses of morphia. As a general rule, it is most marked when there is comparatively little destructive ulceration. Referred and sympathetic pains in back, breasts, and legs are also much complained of. The hæmorrhage may at first be merely an exaggeration of normal menstrual periods, but later on the loss of blood is often continuous and may be associated with a discharge of horribly offensive muco-pus and cancerous débris. The appearance of a hæmorrhagic discharge after the menopause should always determine a careful local examination of the pelvic viscera. Loss of flesh, debility, and the ordinary phenomena of a cancerous cachexia, are gradually developed, and to these may be added special symptoms due to implication of the bladder and bowel.

On *vaginal examination* the physical signs corresponding to the type of disease make themselves evident. There may be merely a nodular thickening of the cervix; or an ulcerating papillomatous mass, like a cauliflower, may project into the vagina, invading the wall of this tube; or the finger may pass through the open os into a ragged hollow cavity lined by an ulcerating mass of new growth. The most careful attention must be given as to the lateral extension of the growth into the broad ligament, whether the uterus is mobile or fixed, and whether the vaginal wall is much involved, as it is upon these facts that the possibility or not of operation depends. It is useless to attempt removal when the broad ligaments are badly invaded, or if the vaginal wall is extensively implicated, or the uterus firmly fixed to bladder or rectum.

In early doubtful cases where the os is ulcerated to a slight extent, a portion of the growth should be snipped away, and submitted to microscopical examination.

Radical Treatment is only practicable when the disease has not extended too far. Formerly gynæcologists used to practise amputation of the cervix when the disease was apparently limited to this region. In the light of modern pathology such a procedure is unscientific and insufficient, and clinical experience has shown that the only operation which should be considered is complete hysterectomy.

Hysterectomy for carcinoma uteri may be performed by the vaginal route or through the abdomen. (1) The *vaginal* operation is possibly a little safer, but has the objections that the broad ligaments cannot be dealt with quite so satisfactorily, and that should adhesions exist it will be difficult or impossible to deal with them. However, in simple early cases it will suffice, and, indeed, when the disease is so extensive as to need more than a vaginal procedure, it has probably gone so far as to be practically inoperable. For details of this operation, gynæcological text-books must be consulted. (2) *Abdominal* hysterectomy is the more scientific procedure, and should always be performed where the local and general conditions of the patient are satisfactory. *Wertheim's* pan-hysterectomy is the operation generally adopted, if it be practicable; it involves the removal of the complete uterus, together with the upper part of the vagina, the whole of the broad ligaments, and the cellular tissue and glands along the iliac vessels. An important preliminary consists in a thorough scraping, cauterization, and disinfection of the diseased cervix. The operation itself is conducted in the Trendelenburg position through a median subumbilical incision, the intestines being carefully packed off from the pelvis by suitable gauze swabs. The local condition of affairs having been fully investigated, the ureters are exposed by an incision along the posterior pelvic wall just behind the base of the broad ligament on each side. Each ureter is traced forwards to the bladder, and if this be done carefully the blood-supply is not impaired, and although the ureters are isolated they will not slough. In this dissection the origin of the uterine artery is laid bare, and divided between ligatures, whilst the broad ligament is also divided as close to the pelvic wall as possible after ligaturing the vessels entering it. The peritoneum in front of the uterus is next divided, and the bladder dissected forwards as far as the anterior fornix of the vagina; a similar dissection frees the rectum from the back of the uterus, which is now merely held in position by its vaginal attachments. This latter tube is then secured by two suitable right-angled clamps, and divided between them. Finally, if the patient's condition warrants it, the peritoneum is divided upwards over the iliac vessels, and the cellular tissue and all enlarged glands removed as high as the bifurcation of the aorta. The cavity left is carefully packed with iodoform gauze projecting into the vagina, and the peritoneum accurately sutured transversely over it. The mortality of this procedure is high (20 per cent.), but with improved technique this is diminishing. The chief risks are infection of the peritoneal cavity, cancerous dissemination, or injury to the ureters.

Palliative Treatment in inoperable cases consists in staying the hæmorrhage, keeping the parts as free from sepsis as possible, and combating pain by morphia. In some cases it may be permissible to curette the diseased structures, thereby removing protuberant masses which interfere with the escape of the discharge. Radium is of considerable value in these cases (p. 57).

Finally, a word must be added to emphasize the fact that the constant association of this disease with a torn and eroded os suggests the possibility of *prevention* by attending to such lesions and not allowing them to persist indefinitely without treatment.

Chorio-epithelioma (*Syn.:* **Deciduoma malignum, Syncytioma maligna,** etc.) is an interesting condition to which considerable attention has been directed of late. It consists of an overgrowth of the chorionic villi, which constitute a soft bleeding tumour, invading and thinning the uterine wall, and insinuating itself into the venous channels, so that general dissemination of the growth is an early manifestation, the lungs being usually involved first. The growth is a soft, succulent papillomatous-looking mass, involving the body of the uterus, and not unfrequently the fundus, and bearing a close resemblance in structure and physical characters to a vesicular mole; in fact, it may be looked on as a malignant form of this structure. The characteristic histological feature is the presence of large syncytial cells derived from the outer layers of the chorionic villi, which appear as masses of protoplasm, containing many dark nuclei; in addition to these are many smaller cells, irregular in shape, unusually rich in glycogen, and in which division by karyokinesis is the rule. It is unusual to be able to demonstrate typical chorionic villi in the mass, but the peculiar cells are exactly similar in nature to those which occur in the villi. Ovarian changes are not unfrequently observed, in the shape of multiple cysts, due to degeneration of the corpora lutea.

The *clinical* features of a chorio-epithelioma are tolerably characteristic. Occasionally the disease follows a normal pregnancy, and is apparently due to the persistence of a portion of the placental tissue, which takes on malignant action of this peculiar type. In the great majority of cases, however, it is preceded by a miscarriage at a fairly early date, and perhaps a vesicular mole of some size is removed. The hæmorrhagic discharge does not cease, but continues and may become exaggerated. Retention of placental tissue is usually diagnosed, and as a rule the uterus is curretted; if on microscopic examination of the scrapings the characteristic cells of a chorio-epithelioma are found, no delay is permissible, but the uterus must be removed at once. Should the case be left, the hæmorrhagic discharge increases, the uterus becomes enlarged, and evidences of secondary deposits appear, especially in the lungs. The nature of this growth is very malignant, and the patient quickly succumbs. *Treatment* consists in abdominal hysterectomy, which should include the ovaries, and if the case is taken before dissemination has occurred, there is good hope of success.

Affections of the Fallopian Tubes.

Pyosalpinx, or an accumulation of pus in the Fallopian tube, is the result of an inflammation of its lining walls (salpingitis), due to infection either with gonococci (the commonest cause), or with pyogenic organisms spreading from an infected uterus after a miscarriage or confinement, or occasionally with the tubercle bacillus. The process is usually chronic or subacute; if it should commence acutely, the symptoms are so blended with those of the accompanying uterine or peritoneal inflammation as to be scarcely distinguishable. Both tubes are usually affected, and it is not uncommon for suppuration to spread to and involve the ovary.

The inflammation, whether acute or chronic, usually results in blocking, and perhaps complete and permanent closure, of both ends of the tube; the abdominal ostium may be closed by fibrin or by the adhesion of the fimbriated extremity to surrounding viscera. Distension of the tube follows, and it frequently becomes elongated and tortuous (Fig. 580); it may contain a considerable quantity of pus, which, though containing organisms at first, may in time become sterile, the germs dying out. The distended tubes gain adhesions to surrounding parts as a result of plastic peritonitis, and the abscess may burst either into the vagina, into one of the surrounding viscera (bladder, rectum, or small intestine), or into the general peritoneal cavity.

Tuberculous pyosalpinx is due to an infection of the mucous membrane of the tube, which may be primary, the organisms reaching the part through the blood-stream, or secondary to uterine or peritoneal tuberculosis; the latter is the more common. Both tubes are generally affected, and either become distended with curdy pus, which may undergo caseation or calcification, or constitute solid fibroid masses with encapsuled caseous foci, embedded in a dense mass of adhesions. If the disease is primary, it may spread outwards through the abdominal ostium to the peritoneal cavity, and give rise to a tuberculous peritonitis which commences as a pelvic affection and may be shut off by adhesions from the general cavity.

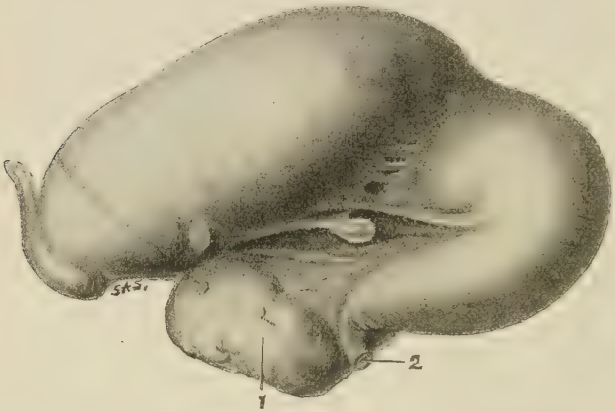

FIG. 580.—PYOSALPINX, SHOWING THE FALLOPIAN TUBE BENT OVER ON ITSELF. (KING'S COLLEGE HOSPITAL MUSEUM.)

1, Ovary; 2, uterine end of tube.

Clinical History.—In the *acute* stage, which is generally seen in gonorrhœal and septic cases, the symptoms are practically those of pelvic peritonitis. The patient lies in bed with the knees drawn up; the temperature is raised, and there may be one or more rigors; the lower part of the abdomen is intensely tender, and vaginal examination reveals little but a generalized painful rigidity and infiltration of all the parts. This condition may persist and pelvic suppuration result, an abscess developing either within the peritoneal cavity, or in and around the broad ligament, and bursting either externally or into one of the viscera. More frequently the acute phenomena gradually subside, and the patient then begins to manifest the signs of a *chronic* salpingitis, which in the majority of cases constitute the initial symptoms. Pain is perhaps the chief manifestation, and this is sometimes of a continuous dragging type, referred to the back and increased on any exertion, or it may only be noticed to any extent at the periods. Not unfrequently the patient is laid up for a week or ten days at a time with these phenomena. If many adhesions are present, micturition and defæcation may also be very painful. The patient is unable to take much exercise, and may walk in a peculiarly cautious manner, bending forwards so as to relax the abdominal muscles, and possibly guarding the lower abdomen with her hands. All these symptoms are increased at the menstrual periods, which are profuse and prolonged, and accompanied by some rise of temperature. When a well-marked collection of pus is present, a hectic type of temperature may persist, and the patient shows signs of toxæmia. The bursting of the abscess into the vagina or one of the viscera may cure the case, if a sufficient exit to the pus is thereby provided. Vaginal examination demonstrates the enlarged and tender tubes; the uterus itself loses some or all of its mobility, and the vaginal vault may feel hard and rigid.

Treatment in the acute cases consists of rest in bed, fomentations to the abdomen and hot vaginal douches, together with opium, if need be, for the pain. In the great majority of cases the only treatment is removal of the tubes, but this should be delayed, if possible, until the acute symptoms have passed. It may be a simple procedure, or an operation of the greatest difficulty, according to the number and nature of the adhesions present. It must be remembered that, although the pus in an old-standing case is likely to be sterile, one cannot rely on this occurrence, and hence every precaution must be taken to guard against infection. It may be possible in some cases to save one or both ovaries, and this is certainly desirable in order to protect the patient from the discomforts of an acute menopause. In a few favourable cases the pus can be reached through the vaginal vault, and an intra-peritoneal operation is thereby avoided; but the indications must be very clear and precise before this method of approach is adopted.

Hydrosalpinx is a condition in which the Fallopian tube is distended with a mucoid secretion, due to the existence of a chronic inflammation which has extended from the uterus, and led to the closure of the abdominal and vaginal openings of the tube. A collection of considerable size may result, and needs to be dealt with by laparotomy.

Tubal Gestation is a condition in which the impregnated ovum commences to develop in the Fallopian tube instead of in the uterus. The causes of this condition are quite unknown, but it may be due to a kink or twist of the tube, whereby the onward passage of the ovum is prevented. Ectopic gestation also occurs within the peritoneal cavity or in connection with the ovary, but these conditions are looked on as always secondary to a primary tubal gestation, the fœtus having escaped from the tube. Any part of the tube may be affected, and hence three forms are described, viz., (1) the interstitial or tubo-uterine, where the growth encroaches on the uterine wall; (2) the true tubal; and (3) the tubo-ovarian or infundibular, where the outer end of the tube is affected.

The muscular wall of the tube stretches and at first becomes hypertrophied; the mucous lining is turgid and congested, and transformed into a decidual membrane. In time the muscle fibres disappear and are replaced by fibrous tissue, and at the placental site atrophy occurs, so that sooner or later rupture of the tube follows, and then the ovum either escapes into the abdomen or into the substance of a broad ligament, and may die or continue its development, the placenta in the latter case gaining a fresh attachment to intestines or other structures. Concurrently with these changes in the tube, the uterus enlarges and becomes lined by a decidual membrane, but is relatively much smaller than usual; at five months it is a third smaller than in an intra-uterine pregnancy, and at full term is about 4 to 6 inches long. Not unfrequently the rupture of a tubal gestation is accompanied by the discharge of a complete cast of the uterus, from which a lochial secretion escapes for a time, and which undergoes involution.

The **clinical history** of an ectopic gestation varies very much in different cases. Occasionally it occurs in a young and healthy primipara, and then is due to some congenital defect of the tube; more commonly it is seen in women who have already borne children or have had some preceding trouble, suggesting the existence of pelvic adhesions or of old salpingitis. Not unfrequently there is a history of a preceding period of sterility, and then a period is missed, the woman not suspecting the existence of pregnancy. There may be some amount of pelvic pain of a crampy nature, and a discharge of a blood-stained character, suggesting the onset of an abortion. In most cases the general signs of pregnancy are absent, since the patient comes under observation at too early a period for their development; but if the condition persists, they may be noticed, though somewhat atypical; the breasts are enlarged; vomiting may occur; but the menses are not always completely stopped. Examination in the early stages might indicate the presence of a well-defined moveable mass on one side of the uterus, constituted by the enlarged tube.

In the early months the great danger is that of *rupture* of the tube, and possibly death from hæmorrhage. Two forms are described:

1. **Primary Intraperitoneal Rupture** usually occurs about the sixth to the eighth week. The tube gives way before the increasing tension

of the ovum, and looks almost as if torn in half. Severe hæmorrhage follows, and the patient either succumbs, or recovers to suffer, perhaps, from a similar condition a few days later. Occasionally the bleeding is less severe, the attacks recurring and being associated with faintness; a localized pelvic hæmatocele is likely to result. In a few cases the ovum regains a vascular connection in the abdomen and continues its development, but generally the pregnancy comes to an end and the ovum dies. The *symptoms* are alarming in the extreme. The patient is seized with severe cutting intra-abdominal pain which is referred to the pelvis, and becomes white, faint, and collapsed. The lower part of the abdomen is exquisitely tender, and the muscles are held rigid and tense. The actual presence of blood in the peritoneal cavity can rarely be demonstrated, but the amount lost is often very great. If the patient survives, she is left in a feeble condition, and often suffers from pyrexia for some days, whilst the pain gradually diminishes. A recurrence of the bleeding may bring the patient into the direst peril; but if it does not recur, absorption commences and may progress uninterruptedly, or a pelvic hæmatocele may result, and this may persist indefinitely or undergo suppurative changes and require operation.

2. **Primary Extraperitoneal Rupture** occurs when the chief development has been downwards and inwards between the layers of the broad ligament. The catastrophe is in these cases somewhat later than in the former class, rupture being delayed sometimes till the seventh to the twelfth week. The loss of blood is necessarily not so great, and the general symptoms are less severe. On vaginal examination the blood tumour can probably be detected by the side of the uterus. The ovum usually dies, and the blood may be absorbed; but not uncommonly infection supervenes and an abscess forms; in other cases a secondary rupture into the peritoneal cavity follows, being associated with the ordinary symptoms of this condition.

Comparatively few ectopic pregnancies continue *after the fourth month*, but should the ovum escape the earlier dangers that surround it, its development may continue either in the tube (very rare) or in the abdominal cavity. The usual phenomena of pregnancy are present, but with modifications. The breasts are less full than usual; the movements of the child under the abdominal wall may be unnaturally obvious to the naked eye; the abdomen is asymmetrically enlarged, and the long axis may even be transverse; palpation of the fœtus may be unduly easy, and the placental souffle exaggerated or misplaced. At full term, or possibly a month or two before it, a form of spurious labour occurs, followed usually by the death of the fœtus. The abdominal swelling diminishes in size, and the uterus undergoes involution with a lochial discharge. The fœtus becomes encapsuled, and may be either mummified, calcified (then constituting a *lithopedion*), or transformed into adipocere; or suppuration sometimes ensues, and the disintegrated fœtus may find its way out through abscesses which burst into the hollow viscera or externally.

Treatment of a Ruptured Tubal Gestation.—In these cases the danger to the patient is that of hæmorrhage, and it is obvious that the rules guiding us elsewhere apply here—viz., that the bleeding point should be exposed and the torn vessels secured. Owing to the fact that the hæmorrhage is concealed, it is possible for the patient to pass into such a condition of collapse as to render operative treatment almost impracticable. In such cases it may be feasible to improve her condition by the infusion of salt solution, so as to justify operation. In other cases where the patient has had one attack of hæmorrhage from which she is recovering, the question of operation is quite open to discussion: on the one hand are the facts that no further trouble need arise, and that the hæmatocele may be absorbed; on the other hand the hæmorrhage may recur, or the hæmatocele may suppurate. It is probable that operation in all cases is perfectly sound advice, especially as one cannot be always certain that the ovum is dead (although the passage of a cast of the uterus is suggestive), and its continued development in the peritoneal cavity is most undesirable. In careful aseptic hands the risks of operation are very small. It goes almost without saying that if a diagnosis of tubal gestation is made prior to rupture, the tube should be at once removed.

Operation for *intraperitoneal* rupture must not be delayed: possibly it may be wise to commence intravenous infusion before opening the abdomen, and to allow an assistant to continue the process during its performance. The patient is placed in the Trendelenburg position; a median incision is made above the pubes; an abundant escape of blood and clots is likely to follow, but the hand is thrust firmly down so as to distinguish the uterus, and thence passes to the ruptured tube, which must be grasped by the uterine attachment and a hæmostatic clamp at once applied; the other end is then sought for. The intervening portion is removed, and the bases securely ligatured. The intraperitoneal clots may be swabbed away or left according to the condition of the patient, and the abdomen either closed entirely or a drainage-tube inserted. The subsequent treatment is that for all forms of hæmorrhage.

The operation for an *extraperitoneal* rupture is slightly different in its characters, since it is usually not undertaken for hæmorrhage, but in order to remove the products of gestation, to relieve the patient from pain, or to prevent a long and tedious convalescence whilst the hæmatocele is absorbing. The possibility that infection may have already reached the sac must not be lost sight of. A median laparotomy is performed in the Trendelenburg position, and the viscera securely walled off by sterile gauze. Intestinal adhesions may be present, and must be cautiously loosened so as to expose the sac of the hæmatocele. This may give way during the manipulations to separate the intestine, or may need to be incised, or is tapped with a trocar. The mass is then isolated, its vessels tied, and complete removal follows; or it may be necessary to evacuate the contents and drain or pack the cavity, especially when the blood has burrowed deeply into the pelvis between the layers of the broad ligament.

When suppuration has occurred, the abscess must be treated on the same lines as are followed in the treatment of a pelvic peritonitis. It may be possible to open and drain from the vagina, or the abscess may have to be dealt with from above.

For the treatment of ectopic gestation which persists after the fourth month, we must refer readers to larger text-books.

Primary Cancer of the Fallopian Tube commences in the mucous membrane, and is likely to run a rapid course, leading to early dissemination of the disease through the peritoneal cavity if the abdominal ostium is patent. The ovary is not unfrequently affected in this way, and careful examination may be required to demonstrate that the primary lesion is in the tube.

Cysts of the Ovary and Broad Ligament.

Many different forms of cyst are developed in this region, and their origin from an embryological standpoint has been already alluded to (p. 230). The following classification may, however, be useful:

I. Cysts directly connected with the Ovary.
1. True ovarian cyst, single, multiple, or proliferating.
2. Paroöphoritic cyst with papillomatous developments.
3. Corpus luteum cysts.
4. Ovarian dermoid or teratoma.
5. Malignant ovarian cyst (usually carcinomatous).
6. Ovarian hydrocele.

II. Cysts of the Broad Ligament.
1. Parovarian cysts.
2. Cysts of Kobelt's tubes.
3. Cyst of Gärtner's duct.
4. Fallopian tube cysts.
5. Lymphangiomatous developments.

True Ovarian Cysts, or, as they should perhaps be better termed, the **cysto-adenomata of the ovary,** are usually multilocular swellings, involving one or both ovaries (more commonly the former), and arising from the tubular ingrowths of the ovarian epithelium or from the Graafian follicles. As the swelling increases, the walls between the loculi thin out and may be absorbed; but the usual appearance is that shown in Fig. 581, where rounded cyst-like masses are seen projecting within the larger cyst, which has been laid open. The fluid is of a tenacious character, somewhat similar in type to mucin, and usually of a yellowish-white colour; if hæmorrhage has taken place into the cyst, the colour is of course modified.

The size of these cysto-adenomata varies enormously; they may be small as an orange, or large enough to compress the abdominal contents and interfere seriously with respiration. The largest cyst of this type we have dealt with contained 32 pints of fluid; the patient was 65 inches in circumference, and her legs were dripping with dropsy; she had been unable to lie down in bed for many months. The walls of the growth vary in thickness and substance; sometimes there is a considerable mass of newly-formed epithelial tissue, which in time would undergo degeneration and form fresh cysts. The cyst is covered externally with peritoneum, and possibly adhesions to omentum or intestine may be present. The broad ligament and Fallopian tube become stretched by the traction and weight of the mass and constitute a well-marked pedicle, which contains the nutrient vessels.

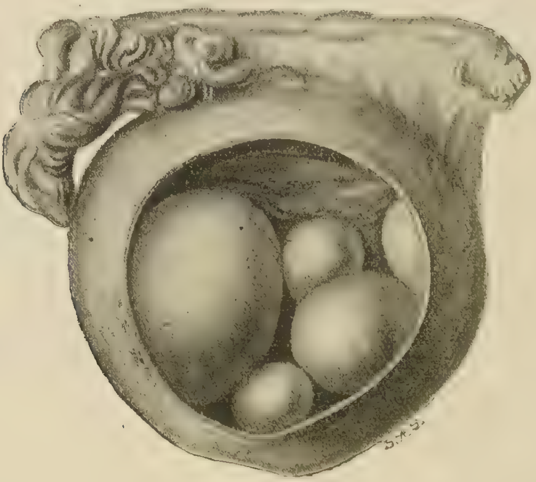

FIG. 581.—PROLIFERATING CYSTO-ADENOMA OF THE OVARY. (KING'S COLLEGE HOSPITAL MUSEUM.)

The main cyst has been laid open to show the smaller cysts which project into its cavity.

Paroöphoritic Cysts are very similar in character to the above, but contain intracystic papillomatous developments (Fig. 582), which not unfrequently burrow through the cyst wall, and may invade the peritoneal cavity, and hence are semi-malignant. The primary growth may be uni- or multi-locular, and in some cases large thin-walled cysts develop containing cauliflower-like excrescences of considerable size, which are covered with columnar epithelium.

Corpus Luteum Cysts are usually multiple and not of great size, though occasionally they may be found as large as a fist. The fluid contained within is more or less thick, and dark in colour from blood extravasation, and the lining wall shows a definite overgrowth of lutein cells. The association of this type of overgrowth with deciduoma malignum has been already mentioned.

For **Ovarian Dermoids or Teratomata,** see p. 228. An ovarian dermoid is usually unilocular; it may manifest its presence at an early age, or not until middle life; it grows slowly, and is very liable to attacks of partial torsion, which may finally become complete.

Ovarian Hydrocele is a condition rarely observed, in which the ovary lies in a pouch in the broad ligament, the mouth of which becomes closed through the development of adhesions, so that a collection of fluid can occur outside the ovary. It is not likely to attain great dimensions.

Parovarian Cysts result from distension with fluid of the parovarium or organ of Rosenmüller, which in reality is the atrophied remnant of the Wolffian body, traces of which can often be seen in the broad ligament. As the cyst gradually increases in size, the layers of the broad ligament are separated, and the ovary and tube are pushed up and stretched over the growth, which usually burrows deeply into the pelvis by the side of the uterus. The cyst is generally unilocular, thin-walled, and contains a clear limpid fluid. Its method of development explains the fact that it has no pedicle.

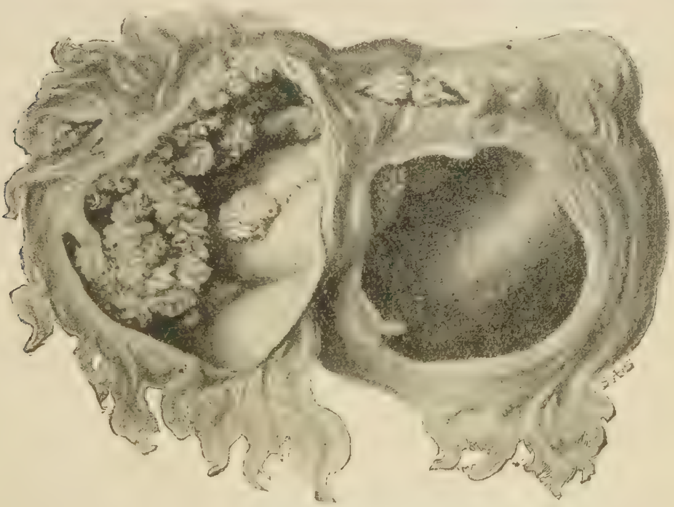

FIG. 582.—CYST OF OVARY (PAROÖPHORITIC) WITH PROLIFERATING PAPILLOMATOUS INTRA-CYSTIC GROWTHS. (KING'S COLLEGE HOSPITAL MUSEUM.)

Cysts of Kobelt's Tubes (Fig. 583) are frequently seen, and are of little significance. It is quite unusual for them to become large enough to cause symptoms.

Clinical History.—It is unnecessary to discuss here *in extenso* the symptoms which arise in the earlier stages when an ovarian cyst is small and intrapelvic. Suffice it that some disturbance of menstruation may occur, usually in the direction of menorrhagia, and that there may be a sense of intrapelvic pressure or pain, and possibly some interference with the bladder or rectum; the latter may be more marked in the broad ligament cysts than in the true ovarian.

The patient is most likely to come under observation when the growth has emerged from the pelvis and become abdominal, and possibly she may have noticed that the swelling appeared first on one side. As it increases in size, it becomes more mesial, and pushes up under the anterior abdominal wall, usually displacing the intestines backwards and towards the sides of the abdomen. Hence on inspection the projection of the growth can often be seen, and there is no bulging of the flanks such as occurs in ascites. Percussion elicits a dull note over the swelling, though the margins may be overlapped by intestine and give a semi-resonant note; the flanks are resonant, whereas in ascites the anterior abdominal wall is resonant, and the flanks and sides dull. Very little or no modification in the percussion note occurs on changing the position from the dorsal to the lateral decubitus, whereas in ascites this produces a marked alteration. On palpation the outline of the cyst may be easily tangible, and it may be felt passing down into the pelvis. A tap sometimes produces a fluid thrill, which is most marked in the unilocular parovarian cysts, and often absent in the multilocular variety, unless the front of the mass is constituted by a single large loculus. It may be possible to demonstrate that the mass is mobile, especially on bimanual examination. The growth is usually found to drag the uterus upwards, and does not project down into the fornices; hence the vagina often appears to be very long, and the cervix is sometimes difficult to reach. The uterus may be displaced laterally.

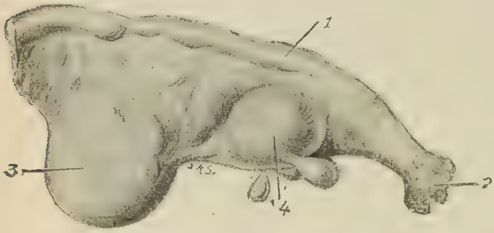

FIG. 583.—CYSTS OF KOBELT'S TUBES. (KING'S COLLEGE HOSPITAL MUSEUM.)

1, Fallopian tube; 2, fimbriated extremity of Fallopian tube; 3, ovary; 4, Kobelt's cysts.

Pressure symptoms of various types arise, such as impaired digestion and constipation, leading to interference with nutrition, emaciation and debility; œdema of the legs is caused by pressure on the vena cava; the subcutaneous veins of the abdominal wall become prominent; and respiration may be considerably embarrassed. Should even a small ovarian cyst become impacted in the pelvis, all the evidences of pressure may be at once exaggerated, and both rectum and bladder are irritable.

Complications of various types ensue, and may quickly jeopardize the patient's life. (i.) *Inflammation* arises from a variety of causes —*e.g.*, traumatism or partial torsion; or germs may gain access from some neighbouring viscus—*e.g.*, the appendix or Fallopian tube. The trouble may be of a slight and localized character, and then merely a few adhesions are developed; or it may be a deep parenchymatous affection, followed by suppuration. The usual phenomena of intra-abdominal inflammation are manifested: the patient complains of pain, and lies with the legs drawn up; the temperature is raised; vomiting and possibly constipation are present; and on palpation the growth is tender, increased in size, and possibly less easily defined. If pus forms, it may escape into the peritoneal cavity or one of the hollow viscera. Even if recovery follows, extensive adhesions may ensue and lead to serious consequences.

(ii.) *Torsion* of the cyst is predisposed to by the existence of a well-marked elongated pedicle, and is most often seen in connection with dermoids; it is impossible in the presence of extensive adhesions. It is probably determined by irregular contractions of the abdominal muscles, and the final disturbance may be caused by definite traumatism. From the fact that in acute cases the pedicle is found twisted on itself two or three times, it is obvious that slight attacks must have preceded the final outbreak of symptoms, and many of the slighter attacks of inflammation (usually supposed to be peritonitic in type) are probably of this nature. Finally, the torsion becomes so severe that the circulation in the cyst ceases, and strangulation ensues. An aseptic peritonitis follows, and unless relief is given in time death from generalized peritonitis and intestinal paralysis follows. The cyst becomes enlarged and engorged with blood; hæmorrhage may occur into its substance, and gangrene is likely to follow. The symptoms may come on suddenly after some effort, or there may be no obvious cause. Pain of a severe character is complained of, followed by shock; the tumour is obviously increased in size, tense and tender; vomiting and constipation suggest the existence of an acute intestinal obstruction, and if the case is not seen till late and there is no definite history of a cyst to be obtained, a diagnosis may be difficult or impossible apart from an exploratory operation.

(iii.) *Rupture* of the cyst may be spontaneous from gradual thinning of the walls, or due to traumatism. The results vary with the contents. A sudden rupture leads to severe pain and shock; this may be followed by inflammatory phenomena and peritonitis if the contents are of a sticky colloidal character, but, when limpid and serous, the fluid may be absorbed, and no harm follows. The cyst itself collapses, and is likely to develop adhesions, but the secreting substance persists, and the cavity may fill up again.

It is impossible to discuss fully here the **Diagnosis** of ovarian cystomata, and it must suffice to point out that the passage of a catheter eliminates the question of a distended bladder; that careful attention to the percussion phenomena, both in the dorsal and lateral decubitus, should suffice to determine the existence or not of ascites; and that vaginal examination and the passage of a uterine sound should eliminate uterine conditions that might be mistaken. Before the introduction of a sound it is of course essential to exclude the possibility of pregnancy. The absence of changes in the cervix uteri and in the breasts, the non-existence of a uterine souffle on auscultation, or of a history of amenorrhœa, morning sickness, etc., should suffice to determine the absence of this latter condition.

Treatment for nearly all varieties of ovarian cyst is the operation of *Ovariotomy*, first performed in 1809 by Dr. Ephraim McDowell in Danville, Kentucky, and that with success. The essential idea of the operation is the removal of the cyst, and this may be accomplished either with or without tapping. The size of the growth will to some extent determine whether or not it should be tapped, but there are some conditions where it is unnecessary (*e.g.*, in small cysts), and others where it is undesirable (*e.g.*, dermoid cysts, and the proliferating papillomatous forms); in these latter there may be active cells in the fluid contents, and the escape of these into the peritoneal cavity (and it is not always possible to prevent such escape) may result in infection of the peritoneum with these cells, and a new development of some form of epithelial growth may ensue.

Operation.—The patient is prepared in the usual way, the abdominal wall being purified and the vulva shaved; but unless there is some objectionable discharge, there is no need to douche or pack the vagina. The Trendelenburg position may be advisably adopted, as it enables the surgeon to deal with the pedicle of the cyst more easily. An incision is made in the middle line above the pubes, and the anterior wall of the cyst is exposed. The finger or hand is swept round in order to ascertain whether or not there are any adhesions; if present, it may be possible to deal with them at this stage, but more usually it is easier to detach them later on. A Spencer Wells trocar is then thrust into the cyst, and as the fluid escapes, the relaxed wall is grasped by forceps and drawn up out of the incision so as to prevent the fluid getting into the peritoneal cavity. This end is not always attained, as the cyst wall is sometimes so soft and friable that it splits and bursts, and any attempt to grasp it with forceps leads to an increased rent in its substance. Under these circumstances the patient can either be rolled over on her side, and the contents scooped out by the hand, or, possibly better, the incision is rapidly increased in length to a sufficient extent to allow the whole cyst to be lifted up out of the abdomen. Large secondary cysts may be opened by the trocar through the first main cyst, but in doing this care must be taken not to thrust the instrument through the posterior or lateral wall of the growth. The pedicle is now securely tied off, and any form of ligature which involves its transfixion will suffice. It is perhaps wise to divide the pedicle at such a distance from the ligature that the main ovarian vessels can be recognised on the stump, and an ordinary silk or catgut ligature can be separately applied to each of these; this plan will obviate any danger that might arise from the relaxation or slipping of the main ligature. The other ovary is then examined and dealt with according to circumstances. The peritoneal cavity is cleansed, and possibly when much of the cyst fluid has escaped it may be desirable to wash it out with salt solution, and the abdominal incision is then closed.

Broad ligament cysts (parovarian) often have no pedicle, and then must be enucleated after tapping. The layers of the broad ligament are divided in a suitable manner back and front; the supplying vessels are secured by ligature; and the cyst wall can usually be freed from its surroundings without difficulty. The opening in the broad ligament is subsequently stitched up, and probably no drainage will be required.

An ovarian cyst with a twisted pedicle is treated in the usual way after untwisting. An inflamed or suppurating cystoma must be dealt with according to circumstances; it may be possible to remove it *en masse,* but incision and drainage without removal may have to be resorted to.

An uncomplicated ovariotomy is one of the most successful major operations in surgery, and the death-rate is now phenomenally small. The presence of adhesions and other complications of course adds to the gravity and increases the death-rate.

Solid Tumours of the Ovary are not very common, and consist of carcinoma, sarcoma, or myo-fibroma. *Carcinomata* are solid or cystic; they grow rapidly, and early involve surrounding parts, producing a generalized carcinomatous infection of the peritoneal cavity with ascites. Bland-Sutton* has pointed out that in the majority of cases cancer of the ovary is secondary rather than primary, and that the causative lesion may be found in the intestine, Fallopian tube, or breast. *Sarcomata* are usually more or less firm, and of the spindle-celled type, thereby closely simulating the *myo-fibromata;* in the former, however, the growth is more rapid, and ascites is more likely to be present. In all these cases extirpation should be practised, if possible.

Salpingo-oöphorectomy, or removal of the ovary and its tube, is required in many conditions—*e.g.*, small solid or cystic tumours, hydro- or pyo-salpinx, and sometimes for dealing indirectly with inoperable carcinoma mammæ. The operation may be simple in the extreme, or one of the greatest difficulty if many adhesions are present. The Trendelenburg position is adopted; the usual mesial incision is made; the ovary is secured, and silk ligatures are carried through the broad ligament and tied above and below to secure the ovarian vessels. After removal of the tube and ovary, it is advisable to secure separately the chief vessels on the face of the stump. Adhesions are dealt with as may be required.

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* *British Medical Journal,* January 4, 1908.

CHAPTER XLIV.

AMPUTATIONS.

By the term **Amputation** is meant the removal of some portion of the body which is injured or diseased to such a degree as to endanger the patient's life, or to preclude any hopes of its restoration to a normal, or even useful, condition. In this chapter we shall merely deal with the operation as applied to the extremities, amputations of organs such as the breast and penis having been described elsewhere. Necessary limitations of space force us to treat the subject somewhat briefly.

Methods of Amputations.—Since the introduction of anæsthesia, the methods employed for the purpose of removing limbs have been almost revolutionized; there is now no necessity to hurry through the operation, and hence many new proceedings, and these sometimes of a most complicated nature, have been devised. They are in the main merely modifications of three cardinal operations —the circular, the racquet-shaped, and the flap.

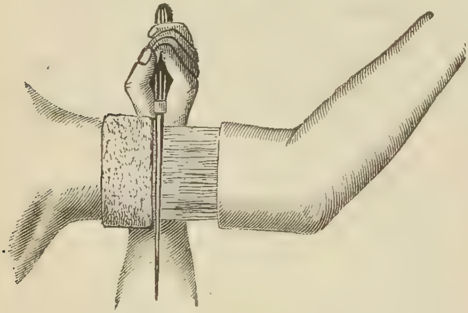


Fig. 584.—Circular Amputation for the Arm, showing Flap of Skin turned back, and Knife applied for Division of the Muscles.

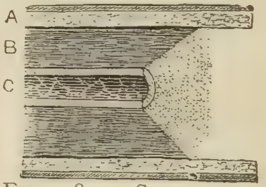


Fig. 585.—Section of Parts after Circular Amputation.

A, Skin and subcutaneous fat; B, muscles; C, bone.

The **Circular Amputation** (Fig. 584), although formerly much employed, is now but little used; in it the skin and subcutaneous tissues are divided around the whole circumference of the limb by a circular sweep of the knife. These are then retracted or dissected back like a cuff, and the superficial muscles divided in a similar manner. The soft parts are again further retracted, and the deeper muscles divided, allowing the bone to be cleared and sawn through at a still higher level. The end of the bone is thus placed at the apex of a conical hollow (Fig. 585), and can be completely covered over; the vessels, moreover, are divided transversely. The stump is not very shapely, and after a time, owing to the shrinking of the soft parts, the cicatrix is likely to become attached to the bone. The arm is almost the only situation in which a pure circular operation is ever undertaken at the present day; but a modified form is still occasionally utilized elsewhere. Thus, one or two vertical incisions may be associated with the circular cut, in order to facilitate the removal of the bone at a higher level, as in disarticulation of the hip-joint by Furneaux Jordan's method (p. 1340).

The **Racquet-shaped Method** (Fig. 590, A and C) is very similar to the last-described modification of the circular. In it an oval incision is made around the limb with one end pointed, and if necessary prolonged upwards to form, as it were, the handle of the racquet. This method is useful for removing fingers and toes, and is also employed at the hip and shoulder joints.

A somewhat similar operation is known as the **Elliptical** or **Oval Method.** In it an oval incision is made around the limb; the lower or distal portion is then dissected up so as to enable the amputation or disarticulation to be completed at a level a little below the proximal end. The free convex border of the flap is then turned over, and fitted into the concavity of the wound.

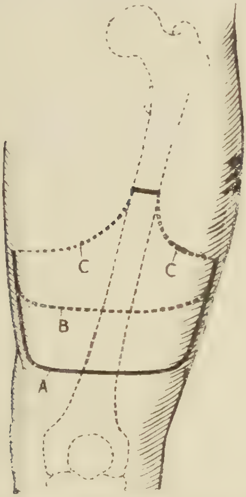


FIG. 586.—AMPUTATION OF THE THIGH BY LISTER'S FLAP AND CIRCULAR METHOD.

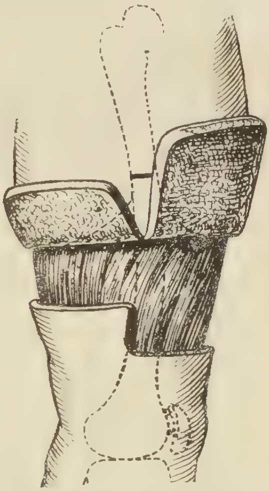


FIG. 587.—LATERAL VIEW OF THE SAME OPERATION WITH THE SKIN FLAPS DISSECTED BACK.

A indicates the anterior flap; B, the posterior, which is half the length of the anterior; C, the line of division of the muscles, which is performed by circular sweeps of the knife.

The **Flap Method** is that chiefly made use of at the present day in amputating through the shafts of the long bones. It was formerly performed by *transfixion* in order to save time; but the bulk of muscles included in the flaps, and the fact that the vessels and nerves are often sliced longitudinally, render this an undesirable proceeding. Hence it has been discarded, and the flaps are now usually marked out superficially, and then raised by *dissection*. As a rule, they consist merely of skin, subcutaneous tissue, and deep fascia, a little muscle being perhaps included towards the base.

The best method of amputating in muscular parts, such as the thigh, is that known as the **Modified Flap and Circular** (Figs. 586 and 587), which was originally suggested by Lord Lister. In this two rectangular flaps with the corners rounded off are raised on opposite sides of the limb, the length of the anterior being two-thirds of the diameter of the limb at the point at which it is proposed to divide the bone, and the posterior flap half the length of the anterior. These, consisting merely of skin and subcutaneous tissues, are dissected up; the muscles are then divided circularly, being retracted for another half-diameter. The advantages of the flap and circular methods are thus combined. In cutting the flaps it is most essential that they should not taper, but should remain the same breadth throughout, the corners being merely rounded off.

General Remarks on Amputations.

Certain important details must always be attended to by the operator when selecting an amputation suitable for any particular case.

1. A **Sufficient Covering** is necessary in order to protect the end of the bone from injurious pressure. If the skin were not contractile, and if the muscles did not retract, it would suffice to provide two flaps, each equal to half the diameter of the limb at the point of section of the bone; but owing to the contractility and retraction of living tissues, it is essential to allow at least a diameter and a half, and sometimes two diameters; in non-muscular parts the former may suffice, but in fleshy parts, especially when amputating low down in the thigh, where the range of muscular contraction is much greater, the latter. It is usually a matter of some significance whence the flaps are derived; thus, a *single* flap, *e.g.*, a long anterior or posterior, is not to be recommended owing to the difficulty of maintaining its nutrition. *Equal* flaps are used in parts like the arm, where the end of the stump will not be exposed to pressure. Generally, however, one flap is cut longer than the other, as in the case of the modified flap and circular, the longer flap being taken from that side of the limb which has the better blood-supply. *Teale's amputation* (Fig. 588) consists in raising a long square anterior flap, equal in breadth and length to half the circumference of the limb at the point of section of the bone, and including everything down to the bone. The posterior flap is similar in nature to the anterior, but only a quarter of its length. The free end of the anterior flap is doubled over, and accurately stitched to the posterior. The advantages claimed for this operation are that the vessels are cut long, and thus the nutrition of the flaps is secured, whilst a covering nearly equal to two diameters of the limb is provided. The great objection to the method consists in the amount of the limb which has to be sacrificed on account of the length

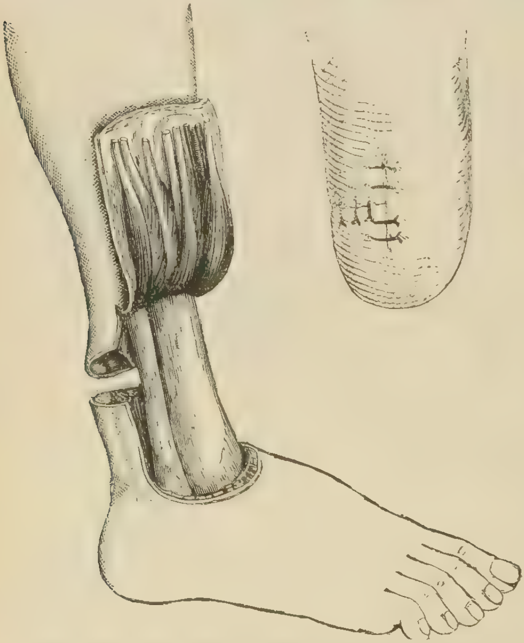


FIG. 588.—TEALE'S AMPUTATION. (TREVES' 'OPERATIVE SURGERY.')

The smaller block indicates how the flaps are brought together.

of the anterior flap, and hence it is rarely employed. Occasionally the covering is derived from the sides of the limb (amputation by *lateral flaps*).

2. The **Cicatrix** should be situated away from the end of the bone, especially in the lower extremity, where the weight of the body has to rest upon the stump.

3. A **Dependent Opening** is desirable for purposes of drainage, and to ensure this the anterior flap is often made longer than the posterior. This, however, is not such an important matter since the introduction of aseptic methods.

4. All these objects should be attained with as **little sacrifice of the limb as possible,** since the higher the operation, the greater the shock to the patient.

As to the operation itself, the greatest care must be taken to maintain **Asepsis,** since muscular and fascial planes have been freely opened, and possibly the medullary cavity of the bone exposed; the dangers of infection under such circumstances are obvious. **Hæmorrhage** is prevented by previous exsanguination of the limb by elevating it for two or three minutes, and then applying an elastic tourniquet. In the leg a piece of rubber tubing may be employed, Samway's tourniquet being perhaps the best. In the arm, however, paralytic symptoms, usually involving the musculo-spiral nerve, have followed the use of such appliances, especially when made of solid rubber; a flat elastic bandage carried several times around the limb, and secured by a knot or with a safety-pin, is all that is needed. Should the tourniquet have to be applied close to the area of operation, it must, of course, be first sterilized; it is also advisable to protect the skin over which it is placed by a few layers of gauze. After the limb has been removed, the main vessels are at once ligatured, both artery and vein being separately tied. It is well to isolate and draw them down for a little distance, so as to make sure that they have not been buttonholed. Any other vessels which can be seen are tied before the tourniquet is removed. An assistant should for a time be ready to control the main trunk after releasing it from the tourniquet. In some cases it may be impracticable or undesirable to apply a tourniquet, and then the main vessels may be temporarily controlled by digital compression at some suitable spot whilst the amputation is completed. All bleeding points are rapidly secured by pressure forceps and subsequently tied, and the main trunks isolated, and clamped or ligatured before division.

For special methods of controlling the hæmorrhage in amputation through the hip-joint, see p. 1339.

Attention has already been drawn to the necessity of not tapering the flaps, but of cutting them square, the corners alone being rounded. In dissecting them up, the deep fascia should be included with the flap, and the blade of the knife always turned towards the part which is to be removed, so that the under surface of the flap, and with it the nutrient vessels, shall not be scored. Whilst dividing the muscles, the flaps must be carefully guarded by the hands of assistants. Before sawing the bone, it is recommended that the periosteum should be retracted for some distance, so as more efficiently to provide for its nutrition; this plan should certainly be adopted for the humerus and femur Any irregular bony spicules left after sawing should be trimmed off with cutting pliers. Attention must next be directed to the main nerves and to any tendons which lie exposed in the wound, all such structures being cut short, the nerves as high as possible. It is always well to cover in the end of the bone by stitching the stripped-up periosteum and subsequently the muscles together over it, and the little extra time expended in the introduction of these buried stitches will be well repaid in the increased shapeliness of the stump. The incision in the skin is usually closed by a continuous suture, and provision made for drainage from one of the angles of the incision. The dressing is applied in such a way as to draw the flaps down over the end of the bone, and a splint is generally necessary in order to control the upper ends of the divided muscles and to keep them from spasmodic contractions.

The chief **Complications** likely to arise in the subsequent course of the case are shock, reactionary hæmorrhage, and those which result from infection; these conditions and their treatment have been described elsewhere.

In a **Healthy Stump** the end of the bone is rounded, and the medullary cavity closed by a layer of compact tissue. The divided muscles and tendons are either incorporated in the cicatrix, or gain fresh adhesions to the bones. The vessels are obliterated as far as the next patent branches, whilst the nerve-ends usually become bulbous (Fig. 123, p. 373), but, if suitably shortened, do not adhere either to the end of the bone or to the cicatrix, and hence give rise to no trouble. A sufficient covering of non-adherent skin and subcutaneous tissue should form a pad for the protection of the bones.

Affections of Stumps.—(*a*) *Necrosis* of the end of the bone is sometimes the result of carelessness on the part of assistants, who can readily denude it of its periosteum by rough sponging, etc.; it rarely follows if the periosteum has been first retracted before the bone is divided; and practically never apart from infection. A small annular sequestrum is usually all that separates, but should the inflammation spread up the medullary cavity (*acute traumatic osteomyelitis*), a more extensive destruction of bone tissue follows (for symptoms and treatment of which see p. 567). (*b*) *Sloughing of the ends of the flaps* occurs in debilitated individuals, especially if thin skin flaps have been employed, or if their nutrition has been impaired by trauma, or if unhealthy tissue has been incorporated in their substance by amputating too close to the seat of disease or injury. The process is usually limited in extent, and rarely calls for treatment other than keeping the part dry and aseptic, the slough being then slowly absorbed; if infection is present, the consequences may be very serious, even necessitating re-amputation at a higher level. (*c*) A *conical stump* results either from the flaps being cut too short, or from the parts shrinking as a result of suppuration, or in young people from continued growth of the upper epiphyseal cartilage of the divided bone. In bad cases the bone may even project through the integument, and necrose; re-amputation is the only treatment. (*d*) A *painful stump* is usually due to the adhesion of a bulbous nerve-end to the cicatrix or bone, so that it is dragged upon at each movement of the limb. The pain is of a severe neuralgic nature, and is treated by excising the bulb, or re-amputation. (*e*) A *spasmodic stump* sometimes occurs, being due either to irritation of the enlarged nerve-ends, or to some central cause. In the former instance, excision of the bulbs or re-amputation will cure the case; in the latter, the trouble will persist in spite of treatment, affecting fresh groups of muscles after re-amputation.

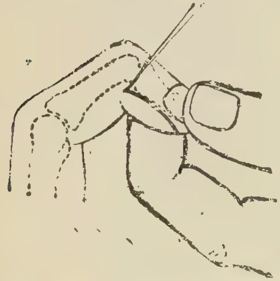


FIG. 589. — INCISIONS FOR AMPUTATION OF TERMINAL PHALANX OF FINGER.

Special Amputations.

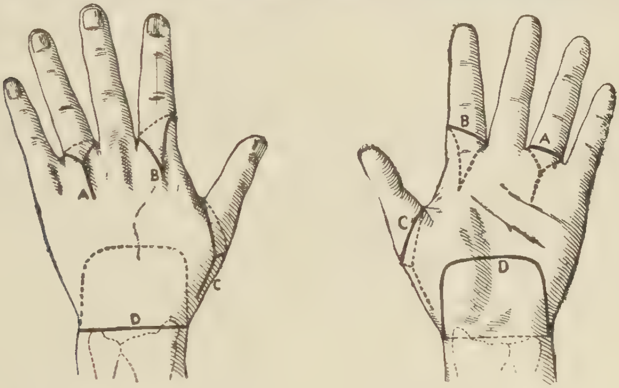
Amputation of the Fingers is frequently required after machine accidents and similar injuries, or in necrosis following a whitlow. In these cases it is often impossible to follow any regular routine, the flaps being obtained from any portion of sound tissue present. The following, however, are the chief plans adopted:

Amputation of the Terminal Phalanx is usually conducted by opening the joint on the dorsal aspect, and cutting a palmar flap from the pulp of the finger (Fig. 589).

No useful result follows amputation through the first inter-phalangeal articulation, since the portion left is practically fixed and useless, no tendons being inserted to govern it. An operation which is sometimes advantageous consists in amputating through the middle of the second phalanx, so as to leave the insertion of the flexor sublimis tendon, the flaps for such an operation being derived from any part of the finger, and the bone divided by cutting pliers.

Removal of a finger **at the Metacarpo-phalangeal Joint** is an operation frequently necessary. It is best conducted by means of a racquet-shaped incision (Fig. 590, A), which starts over the knuckle, extends between it and the next finger, curves round to the palmar aspect so as to be placed a little below the crease in the skin at the root of the finger (Fig. 590, A), and returns in the same way to the back of the knuckle. This incision can be made with one sweep of the knife, but there is no real advantage in such a procedure. The articulation is then opened from behind; the structures on either side are successively divided, making them tense by rotation of the finger, and the flexor tendons finally cut across. Bleeding points (usually one on each side) are secured, and the wound closed.

The question of removing the head of the metacarpal bone is one which must be decided by the occupation of the patient; if he is a working man, or needs strength of hand, it should be left, as its removal always causes weakness. In ladies and those where smallness and elegance of the hand are required rather than strength, it can be taken away by slightly prolonging the incision upwards, clearing the bone on either side, and applying cutting pliers. The gap between the adjoining fingers can in this way be almost obliterated. It is especially advisable to do this in the case of the index-finger, since the head of the second metacarpal bone forms an unsightly projection, and is very exposed to injury. For this finger, Farabœuf's method (Figs. 590, B, and 591, B, and p. 1332) is often used.



Figs. 590 and 591.—Dorsal and Palmar Views of Hand with Incisions for Various Amputations.

A, Incision for amputation of finger by racquet method; B, Farabœuf's method of amputation, as applied for index-finger; C, racquet-shaped incision for disarticulation of thumb at carpo-metacarpal joint; D, amputation through the wrist by a long palmar flap. In all of these the continuous black lines indicate the portions of the incisions visible from the dorsal or palmar aspects respectively; the interrupted lines, the portions that are hidden.

Occasionally the four fingers and their attached metacarpal bones have to be removed *en bloc*. Short equal flaps may then be cut from the front and back of the hand, and the disarticulation effected. The stump that remains, although consisting merely of the carpus and thumb, is very serviceable.

Amputation of the Thumb should never be undertaken unless absolutely necessary, since its removal seriously impairs the functional utility of the hand; as large a portion must be saved as practicable, so as to assist the patient in grasping. The phalanges may be removed by any method which enables the bone to be covered with the least possible sacrifice.

When it is also necessary to take away the metacarpal bone, one of the two following plans should be adopted:

1. *The racquet method* (Figs. 590, C, and 591, C). In this an incision commences in the intertendinous hollow known as the *tabatière*, and extends along the dorsum of the thumb to the head of the metacarpal bone, the oval portion sweeping round it at the level of the web when the thumb is abducted, and on

the palmar aspect corresponding to the oblique crease at its root. The remainder of the operation resembles that for removal of a finger. Care must be taken not to wound the trunk of the radial artery as it passes through the base of the interosseous space; the blade of the knife is therefore kept closely applied to the bone.

2. By a *palmar flap*. In this the knife is first carried across the dorsal aspect of the thumb, from the centre of the web between it and the index-finger, to a point on the palmar surface of the wrist just above the thenar eminence. The knife is then rotated so that its cutting-edge looks outwards, and inserted deeply through the ball of the thumb, transfixing it, so as to emerge at the same spot in the centre of the web as that at which the incision commenced. A muscular flap with a well-rounded border is readily fashioned by cutting outwards. The remaining soft parts are then divided, and disarticulation completed by opening the joint. It is a prettier and more showy operation than the former, but otherwise has no advantages.

Amputation through the Wrist-Joint is seldom performed except for injuries, and then the flaps must be derived as best they can from healthy tissues. Three chief methods are, however, described: (*a*) In the *elliptical* (Fig 592), the incision takes the form of an ellipse, the highest point being on the dorsum ½ inch below the level of the wrist-joint, and the lowest in the centre of the palm 2 inches below the former. On the ulnar side, the incision passes between the pisiform bone and the base of the fifth metacarpal, whilst on the radial side it crosses the carpo-metacarpal articulation. After dividing the cellular tissue, and dissecting up the palmar flap, the joint is opened from the posterior aspect, and the disarticulation completed. The convex end of the palmar flap is fitted into the concavity of the dorsum, and the cicatrix thus forms a curved line on the back of the stump. (*b*) A *long palmar flap* (Fig 591, D) is sometimes utilized, extending from just below either styloid process down to about the middle of the metacarpal bones, the sides of this flap being parallel to each other. The dorsal incision crosses the carpus horizontally between the two extremities of the former wound (Fig. 590, D). The palmar flap is then dissected up so as to include only skin and subcutaneous tissue, with perhaps a little muscular tissue from the thenar and hypothenar eminences. The wrist-joint is opened from the dorsum, and the amputation completed by the division of the flexor tendons. (*c*) In a few cases, amputation by an *external flap* may be desirable (Dubreuil's method). The incision commences at the junction of the middle and outer thirds of the back of the wrist, reaching down to the head of the metacarpal bone of the thumb, terminating at a point in the palm immediately opposite its commencement. This flap is dissected up, and should contain a certain amount of muscular substance from the thenar eminence. The skin and subcutaneous tissues on the ulnar aspect are now divided by a circular sweep of the knife around the inner side of the limb. Disarticulation follows, and the external flap is carried inwards, and sutured so as to close the wound.

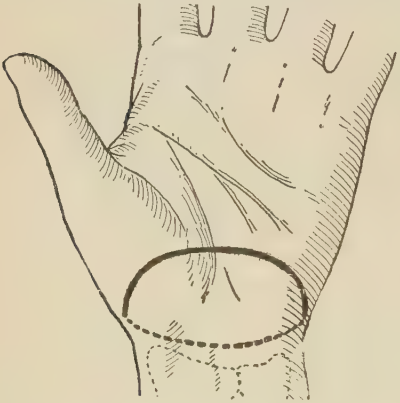


FIG. 592.—AMPUTATION OF THE WRIST BY ELLIPTICAL METHOD.

The dark line indicates the palmar flap, the dotted line the dorsal incision.

Amputation through the Forearm is usually conducted by means of a flap operation, the flaps being either equal in length or one a little longer than the other. The muscles are divided circularly, and the bones should be thoroughly cleared before division

Disarticulation at the Elbow-joint is an operation very rarely seen, and is either undertaken by the elliptical method or with a long anterior flap.

Amputation through the Arm may be carried out by any of the methods described, *e.g.*, the flap, circular, or modified flap and circular, the choice in any particular instance being determined by the requirements of the case.

Disarticulation at the Shoulder-joint.—Three chief methods are practised for the performance of this operation, viz., Spence's, Larrey's, or that by means of an external or deltoid flap. In all, the third part of the subclavian artery may be controlled by digital compression, the surgeon endeavouring to leave the division of the main vessels until the last stage of the proceedings; but it is perhaps better to clamp all the smaller vessels as soon as they are cut, and to isolate and tie the main trunks before their division.

(*a*) *Spence's operation* (Fig. 593).—A preliminary incision similar to that for excision of the shoulder is first made, extending downwards and outwards through the fibres of the deltoid, from a point midway between the coracoid and acromion processes. This passes directly down to the bone, and, if necessary, the joint is at once opened and examined prior to any further steps being taken. The surgeon, standing on the outer side of the limb, then carries his knife from the lower part of the incision downwards and inwards across the axillary folds around the limb to the point from which it first started, thus making the incision racquet-shaped. The skin is first dissected up all round for an inch or so, and then the muscles on the inner side, the deltoid in part, the pectoralis major, the coraco-brachialis and biceps, are divided on the slant, thereby exposing the main vessels and nerves. The vessels may now be secured and divided, and the nerves isolated, pulled down and cut short, or they may be left intact for a time. The soft structures on the outer side of the vertical incision are next separated from the bone, and then the outer half of the capsule, together with the muscles inserted into the greater tuberosity of the humerus, and the long tendon of the biceps, are divided. The inner half of the capsule and the subscapularis are then cut through so as to free the head of the bone. By retracting the external flap and protruding the head from its socket, the posterior part of the capsule can be severed, and then the knife, travelling downwards between the humerus and the axillary vessels, is made to cut its way out, thus completing the disarticulation, the vessels and nerves, if not already dealt with, being divided as the last step in the proceeding. If the knife is kept close to the bone, the trunk of the posterior circumflex artery is not interfered with.

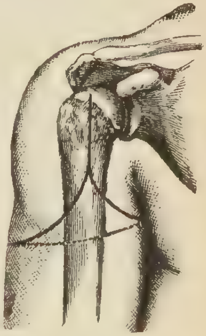


FIG. 593.—SPENCE'S AMPUTATION AT THE SHOULDER BY ANTERIOR RACQUET. (TREVES' 'OPERATIVE SURGERY.')

(*b*) *Larrey's operation* (Fig. 594) is very similar to the above, except that the vertical incision is made on the outer aspect of the joint, reaching downwards from the prominence of the acromion for a distance of about 6 inches, the oval portion starting from its centre, and being directed obliquely downwards and inwards. The tissues are reflected on either side of the humerus; the joint is opened by a transverse cut over the great tuberosity, which also divides the muscles inserted into it. The knife is finally carried down on the inner side of the humerus so as to sever the vessels last, if considered desirable.

(*c*) Amputation by the external or *deltoid* flap is but little practised at the present time. The flap is either cut by transfixion, or dissected up. It is U-shaped, its base extending from the coracoid process in front to the root of the acromion behind. A skin incision is now made across the inner aspect of the limb, joining the ends of the former incision, and extending about 2 inches below the axilla. Disarticulation is then carried out in the same way as in the previous methods.

Occasionally it is necessary to remove the whole of the upper limb together with the scapula and outer third of the clavicle, for new growths, usually of a sarcomatous nature, or for injury. This so-called **Interscapulo-thoracic Amputation** is best performed according to Berger's method. An incision is made along the clavicle, and the middle portion of this bone is then removed so as to enable the surgeon to divide between ligatures the subclavian artery and vein on a level with the lower border of the first rib. The anterior flap is then formed by an incision (Fig. 595) reaching from the centre of the former and extending downwards and outwards over the shoulder, across the anterior fold of the axilla, and as far as the lower angle of the scapula. The pectorales major and minor are divided along this line, thereby exposing the brachial plexus, the constituent nerves of which are severed on a level with the section of the vessels. The axillary space can now be opened up along the outer surface of the serratus magnus. The limb is then rotated inwards and adducted across the trunk, and the patient drawn well to the edge of the table so as to enable the posterior incision, which unites the outer ends of the two former, to be made. The flap thus marked out is dissected up, and the different muscles retaining the scapula in connection with the body are divided one after the other, including the trapezius, omo-hyoid, levator anguli scapulæ, rhomboids, and serratus magnus. These may be incised as near to the bone as is thought compatible with the total removal of the growth. Any remaining fibres are cut across, and the limb is thus detached. In cases of new growth there may be a large number of vessels, both arteries and veins requiring ligature; but in a healthy limb removed for injury, none but the posterior scapular and suprascapular will give any trouble. Naturally, such an operation is accompanied by some amount of shock, but the results usually obtained have been very gratifying.

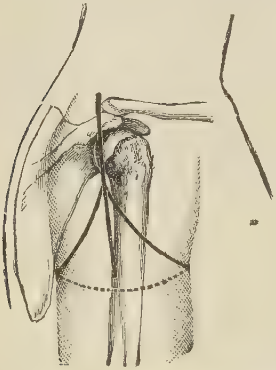


FIG. 594.—LARREY'S AMPUTATION THROUGH THE SHOULDER-JOINT BY EXTERNAL RACQUET. (TREVES' 'OPERATIVE SURGERY.')

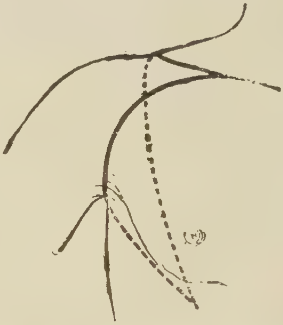


FIG. 595.—INCISIONS FOR THE INTERSCAPULO-THORACIC AMPUTATION.

Amputations of the Lower Extremity.

Amputation of the Toes at the metatarso-phalangeal articulations is precisely similar to the analogous operation on the fingers. It must be remembered that the joint lies as far behind the web as the apex of the toe is in front of it, and hence the incision must start farther back than might be expected.

For the removal of the great toe from the metatarsal bone, *Farabœuf's operation* is the best. The incision (Fig. 594) commences over the head of the latter bone, and well to the inner side of the extensor tendon; it extends downwards nearly as far as the interphalangeal articulation, and then crosses the plantar surface of the toe so as to reach the centre of the web between it and the second toe; thence the knife is carried straight back to the commencement of the incision. These cuts are deepened, the tendons divided, the joint opened, and the toe removed. It will then be found that an internal flap remains, which can be brought across the head of the metatarsal bone, and covers it in so that the L-shaped cicatrix is not exposed to pressure.

Amputation of the great toe at the tarso-metatarsal articulation is conducted either by a racquet-shaped incision, or by dissecting up a flap from the inner side. It is a bad operation, leaving a terribly mutilated foot, and should, if possible, never be undertaken.

Amputation of the foot at the **Tarso-metatarsal Articulation** is performed either by Lisfranc's or Hey's operation.

Lisfranc's amputation (Fig. 597) consists really of a disarticulation, no bone being sawn across. The patient lies on the back with the foot elevated, and extending beyond the end of the table. On the right foot a slightly convex dorsal incision extending down to the bones is made from the tip of the fifth metatarsal bone on the outer side to the base of the first on the inner. The plantar flap is then marked out, reaching from the terminations of the former incision forwards as far as the roots of the toes, and being necessarily longer on the inner than the outside side. On the left foot the incisions are made in the opposite direction. This latter flap is dissected up, the toes being fully extended by an assistant; only the skin and subcutaneous tissues are raised for the first inch, but further back all the structures in the sole of the foot are included. The appearance of the peroneus longus tendon will indicate that the dissection has been carried back far enough. Disarticulation is now performed from the dorsal aspect, the line of the joints (Fig. 598) being kept in mind. The knife is entered behind the spur of the fifth metatarsal bone, and is at first directed forwards and inwards towards the head of the first metatarsal bone. The line of the articulation is then followed as far as the base of the second metatarsal, which projects backwards between the internal and external cuneiform bones. The joint between the first metatarsal and the

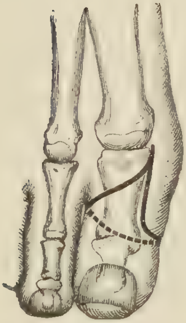


FIG. 596.—FARABŒUF'S AMPUTATION OF THE GREAT TOE. (TREVES' 'OPERATIVE SURGERY.')

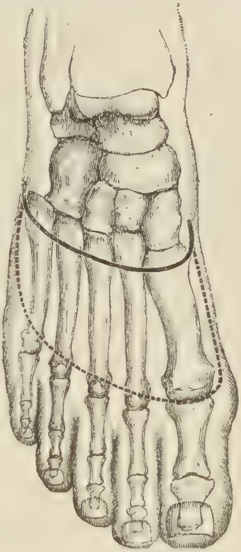


FIG. 597.—INCISIONS FOR LISFRANC'S AMPUTATION. (TREVES' 'OPERATIVE SURGERY.')

internal cuneiform is now opened transversely on the inner side, and the dorsal ligament between the second metatarsal and the middle cuneiform divided. The strong interosseous ligament passing between the internal cuneiform and the base of the second metatarsal is next severed by inserting the point of a knife downwards between the first and the second metatarsal bones, and cutting backwards towards the ankle, elevating the handle of the knife in order to do so. By grasping the toes in the left hand, and forcibly depressing them, the remaining ligaments on the dorsal aspect are divided, and the disarticulation can then be completed.

The plantar flap is sometimes formed as the last stage of the operation, having merely been mapped out in the first instance. In such a case the dorsal incision is first made, the metatarsus disarticulated, and the plantar flap cut from within outwards.

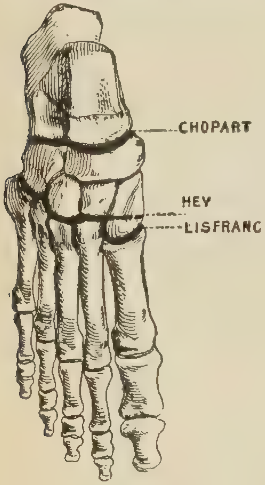


Fig. 598.—Skeleton of Foot, showing Level of Various Amputations.

Hey's operation is essentially similar to the above, with the exception that the projection of the internal cuneiform is sawn across (Fig. 598), leaving a more even surface of bone. It is certainly to be preferred to a simple disarticulation. ***Skey*** advised that the three outer joints should be opened as above, and that then the saw should be applied so as to leave in its mortice the base of the second metatarsal, whilst the projection of the internal cuneiform is removed.

Amputation at the Mid-tarsal Joint (***Chopart's amputation***, Fig. 598) is conducted in a very similar manner to Lisfranc's. A plantar flap with convex end is marked out, reaching on the inner side of the foot from a point immediately behind the tubercle of the scaphoid forwards to within 1 inch of the root of the toes, and terminating on the outer side on a level with the calcaneo-cuboid articulation, *i.e.*, midway between an external malleolus and the spur of the fifth metatarsal. It should be 1 inch longer on the inner than on the outer side. This plantar flap is first dissected up, including everything down to the bones, and then a dorsal incision is made with a slightly convex border. The joints between the astragalus and scaphoid on the inner side, and between the os calcis and cuboid on the outer, are opened from above. Disarticulation is completed by a few touches of the knife, and after all hæmorrhage has been arrested, the plantar flap is drawn up, and united by sutures to the dorsal. Some surgeons prefer to fashion the plantar flap after opening the joints from the dorsum.

Chopart's amputation is not, on the whole, a very satisfactory proceeding, since it consists in the removal of the anterior segment of the arch of the foot, the posterior half being left without support. The natural result of this is that the head of the astragalus travels downwards, and presses upon the anterior portion of the stump, causing a good deal of pain and discomfort, whilst the os calcis is drawn upwards by the traction of the tendo Achillis. Formerly it was considered that the resulting deformity was purely due to unbalanced muscular traction, and hence attempts to prevent it were made by dividing the tendo Achillis, or by stitching the extensor tendons to the under surface of the os calcis. Seeing, however, that the trouble is mainly mechanical, and hence unavoidable, it would perhaps be wiser to avoid the operation entirely, substituting for it a subastragaloid amputation, or modifying it by removing the astragalus after the foot has been taken away. Tripier's amputation has also been utilized to prevent such displacement; in it an oblique external racquet is made, reaching backwards to the anterior border of the tendo Achillis; disarticulation follows at the mid-tarsal joint, and then the os calcis is sawn across horizontally on a level with the sustentaculum tali, so as to leave a broad base of support, which is not so likely to become tilted forwards. It is but fair to say, however, that in not a few cases of Chopart's amputation an excellent stump remains without any of these inconveniences.

A still better modification,* where practicable, is to remove the foot on a slightly anterior plane, *i.e.*, to leave the scaphoid on the inner side, and to divide the cuboid on a level with its anterior border with a saw. The skin incisions can be made as for a Chopart. The stump left is longer, and therefore controlled more easily, whilst the attachment of the tibialis posticus is maintained, and it is easy to give the peroneus longus an insertion, so that the lateral movements of the foot are in great part preserved.

Subastragaloid Amputation of the foot is occasionally possible in cases of injury, where the astragalus remains uninjured. The best plan to adopt is that known as *Maurice Perrin's oval operation*. A racquet-shaped incision (Fig. 599) is made, commencing at the insertion of the tendo Achillis, and extending along the outer border of the foot to a point immediately behind and a little above the spur of the fifth metatarsal, from which it sweeps over the dorsum, along the instep, and after crossing the sole returns to the same spot. The dorsal part of the flap is then dissected up, the astragalo-scaphoid joint opened, the tendo Achillis divided, and by twisting the foot inwards the joints between the astragalus and os calcis can be entered, and the interosseous ligament severed. By still further inverting the foot until it assumes a position of extreme varus, the structures on the inner side of the os calcis can be detached, and by continuing the same torsion, the inner surface of the bone is finally cleared, the dorsal aspect of the foot looking downwards. When the foot has been removed, bleeding points are secured, tendons and nerves cut short, and the wound, which now lies horizontally, is secured by sutures. A very firm basis of support is provided by this operation, and the stump is covered by the skin of the heel, which is accustomed to pressure.

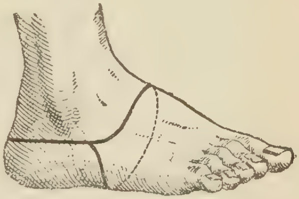


FIG. 599.—RACQUET INCISION FOR SUBASTRAGALOID AMPUTATION.

Amputation of the Foot.—*Syme's amputation* consists of a disarticulation at the ankle-joint, together with removal of the two malleoli and the articular surface of the tibia. The patient lies on the back with the leg well elevated and projecting over the end of the table, the surgeon standing either below or a little to the right of the patient. Having exsanguinated the limb, the operation is, on the right foot, commenced by making an incision from the tip of the external malleolus down to the heel, and extending up to a point $\frac{1}{2}$ inch below and behind the internal malleolus (Fig. 600, A). On the left side the incision is made in the opposite direction. For this purpose a short-handled strong-bladed knife should be employed (an ankle-knife). The incision is directed slightly backwards, otherwise a bucket-shaped heel flap is formed, in which discharges may collect. The knife is carried down to the bone at the first cut, and the surgeon then proceeds to dissect up the heel flap thus marked out by inserting his thumb into the wound, and partly peeling, partly cutting, the soft tissues from the back of the os calcis. This is sometimes a tedious and tiring proceeding, since it is most important to keep close to the bone for fear of dividing the nutrient vessels of the flap (external and internal calcanean) The dorsal incision (A^1) is then made, uniting the ends of the former wound, and carried slightly forwards so as to mark out a short convex flap. This is dissected up, and the ankle-joint opened, the line of the articulation being placed $\frac{1}{2}$ inch above the tip of the internal malleolus. By division of the lateral and posterior ligaments, of the tendo Achillis, and of the few remaining fibrous connections along the top of the os calcis, the foot is removed. The lower ends of the tibia and fibula are then cleared and sawn off (S), the ends of the dorsal flap being meanwhile held out of harm's way. The main vessels are tied, as also any other bleeding points; the tendons and chief nerves are drawn down and cut short, and the wound closed by sutures, provision being made for drainage through one of the angles.

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* *Gaz des Hôpitaux*, January 21, 1902.

A much quicker and prettier method of performing this operation consists in opening the joint, and disarticulating immediately after the incisions have been made, whilst the os calcis is subsequently dissected out of the heel flap from above, keeping the knife close to the bone.

Syme's amputation gives excellent results with only slight shortening, and the patient is able to walk on skin which is already accustomed to pressure. It is specially useful where amputation is required for tarsal disease, inasmuch as it is then rarely safe to undertake any of the partial or more conservative methods of operating.

Pirogoff's operation is one in which the posterior portion of the os calcis is sawn off, and applied to the under surface of the previously sawn ends of the tibia and fibula. The operation here described is not strictly that of Pirogoff, but rather the modification suggested by Sedillot. The patient and surgeon being relatively placed as for Syme's operation, an incision is made extending from the same points, viz., between the tip of the external malleolus and a point ¾ inch below and behind the inner malleolus, but instead of passing directly downwards it is carried obliquely forwards (Fig. 600, B). Everything is divided at once down to the bone, and the dorsal incision is then made, being placed at right angles to the plantar (B^1). The ankle-joint is opened from above, and disarticulation completed; the structures to the side of and behind the joint are then divided, so that a saw can be applied to the exposed surface of the os calcis, and the bone cut in a direction more or less parallel to that of the plantar flap (P^1). The lower ends of the tibia and fibula are now cleared, and the malleolus and articular surface sawn off obliquely, the saw-cut being as nearly as possible parallel to that made through the os calcis (P).[†] The object of this obliquity is to enable the sawn end of the posterior part of the

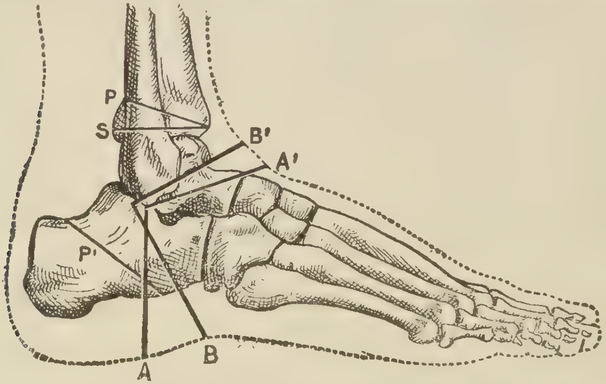

FIG. 600.—LINES OF INCISION IN BONES AND SOFT PARTS IN SYME'S AND PIROGOFF'S AMPUTATIONS.

A, A^1, Incisions for Syme's amputation; B, B^1, incisions for Pirogoff's amputation (these should really start from the same point as in Syme's operation, viz., the tip of the external malleolus, but to avoid confusion they have been placed a little behind it); S, section of tibia and fibula in Syme's amputation; P, section of tibia and fibula in Pirogoff's amputation; P^1, line of section of the os calcis in Pirogoff's amputation.

os calcis to be brought into apposition with the similarly treated ends of the bones of the leg, and wired to them without any traction on the tendo Achillis. By this operation a somewhat longer stump is obtained than in Syme's, and the patient is able to walk on the posterior part of the os calcis instead of on the sawn ends of the tibia and fibula. The operation is more useful in cases of injury than for disease

Amputations of the Leg may be undertaken either immediately above the malleoli (supramalleolar) or in the middle third, or a hand's-breadth below the knee (site of election). In the two former positions almost any operation may be practised according to the needs of the case, but perhaps the most satisfactory is that by means of equal lateral flaps, each of which is equal in length to one diameter of the limb, and consists below of skin, fat, and deep fascia, but for the upper half the muscles are also included (Fig. 602, 1). In dividing the bones, care must be taken not to leave a sharp projecting edge on the front of the tibia. This is best prevented by partially sawing through the bone in an oblique direction from above downwards, and when this has reached a little beyond its centre, the saw is withdrawn, and a horizontal section made, cutting across the oblique incision in such a way as to remove a wedge of bone from the front of the tibia, which thus becomes suitably bevelled. The fibula should always be divided before completing the section of the tibia.

In the lower third of the leg, Teale's amputation (Fig. 588) is sometimes recommended, and gives good results.

Amputation of the Leg at the Site of Election may be performed either by the modified flap and circular operation, or by a large external flap (*Farabœuf's operation*). In the latter, the external flap (Fig. 601, A, C), which is U-shaped, is first marked out with the knife, extending 1½ inches higher in front than behind, and its length being equal to the diameter of the limb at the point at which the bones are to be divided. The incision on the inner side is then made, extending directly across the limb from a point 1½ inches below the upper end of the anterior horn of the former incision to its posterior extremity (B, C). The external flap is dissected up, commencing anteriorly; the fingers and knife being inserted between the tibialis anticus and the tibia, all the soft parts down to the bone and interosseous membrane are divided obliquely. The anterior tibial artery is cut long, and care must be taken not to free the flap from the interosseous membrane too high, for fear of injuring the trunk of this vessel as it passes between the bones, an accident which would seriously imperil the vitality of this large and fleshy mass. The tissues on the inner side of the limb are now divided, either by transfixion or circular division. The interosseous membrane and bones are bared, and the saw applied according to the method already described.

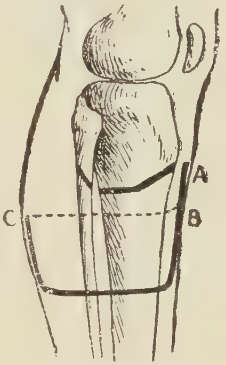

Fig. 601.—Farabœuf's Amputation at the Site of Election, a Hand's-breadth below the Knee.

The continuous line, A, B, C, indicates the shape of the large external flap; the dotted line, B, C, the incision on the inner side of the limb. The direction in which the bones are sawn is also shown.

Disarticulation at the Knee-joint is a very useful and valuable proceeding. The methods chiefly employed are as follows: (i.) *Stephen Smith's operation*, or amputation by equal lateral flaps. The incisions extend from a point immediately below the tuberosity of the tibia backwards in a semilunar fashion, to terminate in the middle line behind on a level with the joint (Fig. 602, 2). The incision on the inner side should reach a little lower than that on the outer, in order to ensure sufficient covering for the inner condyle, which is always larger than the outer. The flaps are dissected up all round, including the subcutaneous and deep fascia, being turned back in front like a collar, so as to enable the surgeon to reach and divide the insertion of the ligamentum patellæ. The knife is now carried along the upper margin of the tibia, separating the attachments of the semilunar cartilages to the bones by dividing the coronary ligaments. The surrounding muscles and tendons are cut through at the same level, together with the crucial ligaments, and the leg is finally separated by boldly sweeping the knife through the soft parts at the back of the joint, the flaps being well retracted. The popliteal vessels are secured, and the flaps drawn together in the median line. When union has occurred, the cicatrix is drawn up behind into the intercondyloid notch so that an excellent hooded covering is provided for the lower end of the femur. The chief objection to the operation is that the upper part of the synovial membrane of the joint remains intact, and may become distended by a serous effusion through the irritation produced by wearing an artificial limb. (ii.) Amputation can be undertaken by a *long anterior flap*, the patella being left *in situ* or removed, according to circumstances. A short posterior flap is also formed and dissected up, so as to enable the muscles and vessels to be divided transversely.

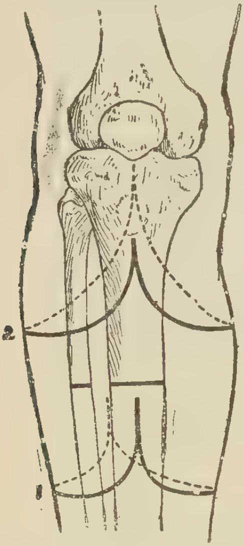

Fig. 602.—Amputation of the Leg by Lateral Flaps; 2, Stephen Smith's Amputation through the Knee-joint.

Supracondyloid Amputation of the Thigh is an operation often requisite in order to deal with disease or injury involving the knee-joint. (*a*) *Carden's amputation*, slightly modified, is one excellently adapted to this purpose. An anterior flap (Fig. 603, A) is fashioned from the most prominent point of one condyle to that of the other, the incision crossing the mid-line in front half-way between the patella and the tibial tubercle. This flap is dissected up in front of the patella as far as its upper border. A short posterior flap is then dissected up (Carden made his posterior incision horizontal). A transverse cut above the patella lays the knee-joint open, and after flexing the limb the lateral and crucial ligaments are divided. The hamstring muscles, etc., are severed by cutting from without inwards, and a few touches of the knife will then serve to disarticulate. The muscles are retracted, and the femur divided a little above the condyles. (*b*) *Lister's modification* (Fig. 603, B) consists in making a transverse incision across the front of the limb on a level with the upper border of the tubercle of the tibia. The horns of this incision are joined posteriorly by carrying the knife downwards at an angle of forty-five degrees to the axis of the leg. This flap is dissected up, and the whole of the integuments and subcutaneous tissues are freed and retracted like a cuff, so as to enable the muscles to be divided circularly just above the patella. The saw is then applied, and the bone removed. By this means the covering of the end of the bone is taken more from the back than from the front of the limb. (*c*) *Gritti's operation* (Fig. 604) is thus performed: A large anterior flap similar to that used in Carden's operation is dissected up, including the patella, and a shorter posterior flap is then fashioned. The soft parts are divided by a circular cut of the knife, and the femur sawn across about the level of the adductor tubercle. The cartilaginous surface of the patella is then removed with the saw, and the remaining portion of the bone secured by a silver wire to the divided end of the femur. Considerable difficulty may be experienced in keeping the patella in accurate apposition, and to obviate this Stokes recommended division of the femur at a slightly higher level—*i.e.*, above rather than through the condyles. (*d*) Amputation by a *long posterior flap* is sometimes required in cases where the tissues in front of the limb have become disorganized from disease of the joint, or when cicatrices produced by a previous excision are present. The posterior flap is first marked out and dissected up, including merely the skin and subcutaneous tissues. A transverse incision is made across the limb above the cicatrices or sinuses, the bone sawn just above the site of the preceding excision, and the posterior muscles and vessels divided circularly. A very good stump usually results.

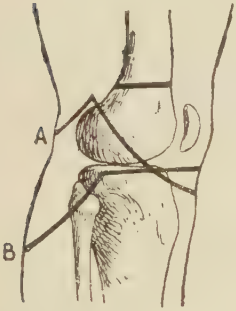

FIG. 603.—INCISIONS FOR SUPRACONDYLOID AMPUTATION OF THE THIGH.

A, Carden's operation; B, Lister's modification of the same.

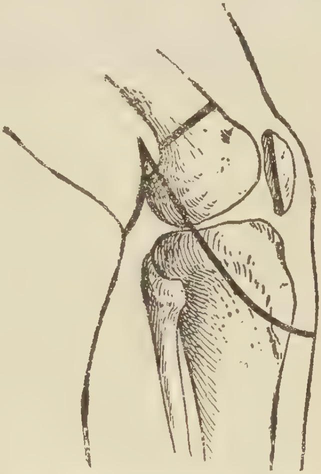

FIG. 604.—STOKES-GRITTI AMPUTATION, SHOWING INCISION IN THE SOFT PARTS AND THE LINES OF SECTION IN THE FEMUR AND PATELLA.

Amputation of the Thigh may be conducted by any of the general methods already described, but Lister's operation, modified flap and circular (Figs. 586 and 587) is perhaps the best.

Amputation through the Hip-joint.—Disarticulation at the hip-joint is always an operation of the greatest gravity, and every precaution should be taken to minimize the immediate risks by preventing hæmorrhage and lessening shock. No part of the body should be unnecessarily exposed, whilst the head is kept low, and although the operation must not be hurried over, no time is wasted.

Perhaps the best way of preventing hæmorrhage is to secure the main vessels before dividing them, and then to take up each bleeding point as it appears; the limb can thus be removed with the loss of merely a few ounces of blood. The only other plan which is at all desirable is that suggested by Wyeth, of New York, which consists in applying a rubber tourniquet close to the pelvic brim, and this is prevented from slipping by inserting long needles immediately below it. The limb is first exsanguinated by elevation, or possibly by the use of an Esmarch's bandage. Two long steel needles, 10 inches in length and $\frac{3}{16}$ inch in thickness, are then inserted, one on the outer side of the thigh and one on the inner. The former is introduced ¼ inch below the anterior superior spine of the ilium, and slightly to the inner side of this prominence, and is made to traverse superficially for about 3 inches the muscles and fascia on the outer side of the hip, emerging on a level with the point of entrance. The point of the second needle is thrust through the skin and tendon of origin of the adductor longus muscle ½ inch below the crutch, the point emerging 1 inch below the tuber ischii. The points should be shielded at once with cork to prevent injury to the hands of the operator. No vessels are endangered by these skewers. A mat or compress of sterile gauze 2 inches thick and 4 inches square is laid over the femoral artery and vein as they cross the brim of the pelvis; over this a piece of strong white rubber tubing, ½ inch in diameter when unstretched, and long enough when in position to go five or six times round the thigh, is now wound very tightly around and above the fixation needles and tied.'* By this means the limb can be removed with very little loss of blood.

Formerly but one operation was utilized for the removal of the limb at the hip-joint, viz., by transfixion, the flaps being cut antero-posteriorly. The great advantage of this method was the rapidity with which it was executed; it has, however, been replaced by other plans, one of which should always be adopted.

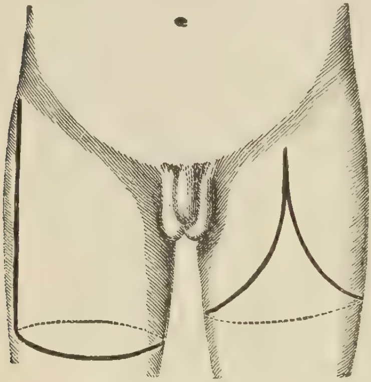

FIG. 605. — AMPUTATION THROUGH THE HIP-JOINT.

On the right leg Furneaux Jordan's method is indicated; on the left leg the flaps required for the anterior racquet operation are shown.

Amputation by an *external racquet incision* (Fig. 605; right leg) has been recommended by many surgeons, especially Furneaux Jordan, Esmarch, and Lister, each of whom has advocated some slight modification. The surgeon should always stand to the outer side of the limb, whilst the pelvis of the patient rests at the extreme edge of the table. The essential features of this operation consist in a circular division of the structures down to the bone below the lesser trochanter, whilst the head of the bone is disarticulated and removed through the external vertical portion of the incision extending downwards from above the great trochanter; it matters little whether the vertical incision is made before or after the tissues in the thigh have been divided. Perhaps the simplest plan of carrying out this operation is as follows: A circular incision is made through the skin and subcutaneous tissues 5 or 6 inches below the great trochanter. These are dissected up for a few inches, and the muscles divided circularly down to the bone, which is at once sawn through. The external incision, 6 or 8 inches long, is then made, the tissues being freed from the anterior and posterior surfaces of the femur, and the rotator muscles divided along the borders of the great trochanter. The lower end of the fragment of the femur is then grasped by lion forceps, and after forcibly flexing and rotating the bone inwards, the capsule of the joint is laid open on its posterior aspect. By everting the bone, the anterior part of the capsule can be reached and incised, and the attachment of the ilio-psoas muscle severed. The ligamentum teres is then divided by inserting the point of the knife into the acetabulum, and the head of the bone is thus set free. One great advantage of this operation is that the incisions are placed as far as possible from the risk of infection from the genital organs and perineum.

In the majority of cases, however, the best method of amputating at the hip-joint is by means of an *anterior racquet incision* (Fig. 605; left leg). This commences over the centre of Poupart's ligament, and is carried down along the course of the main vessels for about 3 inches. The common femoral sheath is exposed, and both artery and vein are secured by double ligature and divided. The incision is then completed; it sweeps over the inner side of the thigh 4 or 5 inches below the perineum to the back, and is brought up again to the front 3 or 4 inches below the great trochanter. The muscular structures in the outer flap are then cut through, and the external circumflex artery and other bleeding vessels secured by pressure forceps *en route*. By rotating the limb inwards, the insertion of the gluteus maximus can be divided, as also the muscles attached to the great trochanter. The muscles in the inner flap are then similarly dealt with after rotating the limb outwards, the internal circumflex artery, etc., being secured. The capsular ligament is next divided transversely, and the head of the bone disarticulated. Finally, the limb is rotated forcibly outwards, and all the soft parts at the back of the limb, including the sciatic vessels and nerves, are divided from within outwards with one sweep of the knife. The wound when sutured lies anterio-posteriorly.

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* Wyeth, *Annals of Surgery*, February, 1897.

CHAPTER XLV.

ANÆSTHESIA.*

The practice of surgery has always been of such a nature as to render some means of abolishing the pain caused thereby a desideratum; but although in the old days various plans were adopted to attain this object, yet it was not until the end of the eighteenth century that any real advance was made in this direction. In 1799 Sir Humphry Davy suggested the possibility of using nitrous oxide gas as a means of rendering patients anæsthetic during surgical work; but, as then employed, it was so uncertain in its action that no great benefit was derived from the knowledge thus acquired, and many years elapsed before it came into extensive use. The demonstration of the properties of ether in 1846 by Long and Morton in America, and of chloroform, in 1847, by Sir James (then Professor) Simpson in Edinburgh, heralded in a new era of surgery. Operations, which before were scanty in number, became greatly multiplied, and at the present day, with our advanced knowledge and experience, and our constant dependence on these agents, it is difficult to understand how surgical practice could have been conducted without them. Anæsthetics have enabled the surgeon to attack almost every region of the body, and instead of operations being hurried over, in order to minimize the patient's sufferings, they are now undertaken with much more deliberation, accuracy being the great requisite of the present day, and not, as formerly, rapidity.

Anæsthesia may be produced in several ways: (1) By temporarily paralyzing the sensitive nerve endings in the immediate neighbourhood of the part to be operated upon, either by freezing or the application or the injection into the surrounding tissues of certain chemical substances which will have that effect (*local analgesia*). (2) By temporarily suspending the conductivity of the main nerve-trunks supplying the affected areas, by injecting into, or around, these nerves chemical substances similar to those used in the former method (*spinal and regional analgesia*). In neither of these methods is the patient rendered unconscious, as is the case in the two following plans. (3) By employing a volatile substance, and administering it by inhalation through the nose and mouth (*inhalation anæsthesia*). (4) By injecting similar volatile substances into the veins, rectum, etc.

1. **Local Anæsthesia** (including *local and regional analgesia*) is utilized where slight operations of short duration are to be undertaken, or occasionally in more serious cases where the patient cannot stand a general anæsthetic. The chemical substances employed for this purpose are, with one exception, all derived from or allied to *cocaine*, which is an alkaloid obtained from the dried leaves of *Erythroxylon coca* (South America). Of the alkaloid itself the salt most frequently used is the hydrochlorate.

Mucous membranes are readily anæsthetized by applying a 5 or 10 per cent. solution to them for about five or ten minutes, the insensibility lasting for about the same time. In dealing with the skin or deeper tissues, hypodermic injections of the drug are relied on, the anæsthesia following the course of the peripheral nerves. The action of cocaine is supposed to depend partly on an anæmic condition of the affected tissues induced by arterial contraction, partly on paralysis of the termination of the sensory nerves. Inflamed tissues are but little affected by it. When applied hypodermically, the needle should be inserted in the line of incision, and the injection diffused equally along it. In making use of this reagent, it must always be remembered that cocaine has a distinctly depressing influence upon the heart, and hence more than ½ grain should never be employed. Should toxic effects be manifested (as by pallor of the face, a cold clammy sweat, giddiness, weak and rapid pulse), the patient's head should be lowered, and stimulants administered. In some parts of the body it may be possible to control the circulation so as to hinder the general absorption of the drug. Thus, for circumcision the base of the penis may be constricted by an elastic band, whilst a similar arrangement may be applied to the fingers and toes for small operations, such as avulsion of a toe-nail.

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* For the revision of this chapter I am indebted to the kindness of Dr. Silk.

The circulation can also be controlled to some extent by adding a few drops of the 1 in 1,000 adrenalin solution to each injection of the alkaloid.

Recent experience with the use of this drug has demonstrated the fact that equally satisfactory results are obtained by injecting larger quantities of much more dilute solutions (1 or 2 per cent.) beneath, as well as all round the site of the operation (*Schleich's infiltration method*).

It has also been found that many of the allies and derivatives of cocaine are equally efficacious and much less likely to give rise to toxic symptoms. Of these substitutes the best known are β-eucaine, stovaine, and novocaine. Of the first of these Barker[*] recommends the following formula:

Distilled water	100·0 c.c.	= 3½ ounces
β-eucaine	0·2 gramme	= 3 grains
Sodium chloride	0·8 gramme	= 12 ,,
One per mille adrenalin chloride solution		10 minims

There are no toxic effects associated with this solution, and as much as 7 ounces may be employed in order to infiltrate the tissues. If allowed to act for thirty or forty minutes, the parts are often found to be not only anæsthetic, but also practically bloodless. Operations of gravity can be performed without pain, including such conditions as strangulated hernia, intestinal obstruction, tracheotomy, thyroidectomy, etc., when a general anæsthetic may be undesirable.

Local anæsthesia is also produced by **freezing** the part, either by the application of ice and salt, or by the ether spray, or with ethyl chloride. The latter reagent is now put up conveniently in small glass or thin metal flasks with a fine capillary outlet; on holding the flask in the hand a spray is produced, which is allowed to play upon the part to be operated on. The rapid evaporation from the surface leads to the freezing of the skin, which becomes of a dead white colour. The anæsthesia produced is of a very fugitive nature, and a certain amount of pain may be associated with the thawing process, but less than that caused by the ether spray.

Of late years considerable success appears to have attended the use of a mixture of quinine and urea (quinine hydrochlor-carbamide), 1 per cent. of the combined drugs, which is absolutely non-toxic in any quantity, but rather apt to produce undue effusion.

2. For the production of **regional analgesia** not only must the nerve-supply of the part be known, but one must also be acquainted with the exact points of emergence of the main nerve-trunks from the deep fascia. Spalteholtz and others[†] have carefully worked out many of these points, but it is obvious that the process is a very difficult and complicated one, and may involve a

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[*] *Brit. Med. Journ.*, December 24, 1904, p. 1638; and *Practitioner*, September, 1907.

[†] Braun, "Die Lokalanasthesie," Leipzig, 1913; Hirschel, translated by Krohn, 'Textbook of Local Anæsthesia,' 1914.

second or additional operation on the same patient. In any of these methods it is of prime importance that the solutions used should be absolutely sterile.

Spinal Analgesia is a condition which results from the introduction within the spinal membranes of some substance which acts upon the nerve centres or roots, and produces insensitiveness to pain in the regions supplied by them. At first cocaine was employed for this purpose, but the after-affects were so troublesome that it had to be given up, and the substance now most generally utilized is **stovaine.** It is prepared in sterilized solution in glass ampoules (Billon) containing 0·1 gramme of stovaine with an equal amount of glucose in 2 c.c. of sterile water. The whole or a part of this is injected into the cerebro-spinal cavity.

The proceeding is very simple in *technique*. A suitable series of needles and a syringe easily sterilizable are provided by most instrument-makers for this purpose. Care must be taken that no alkali is used in the sterilization of syringe or needles, as stovaine is thereby decomposed and becomes inert.

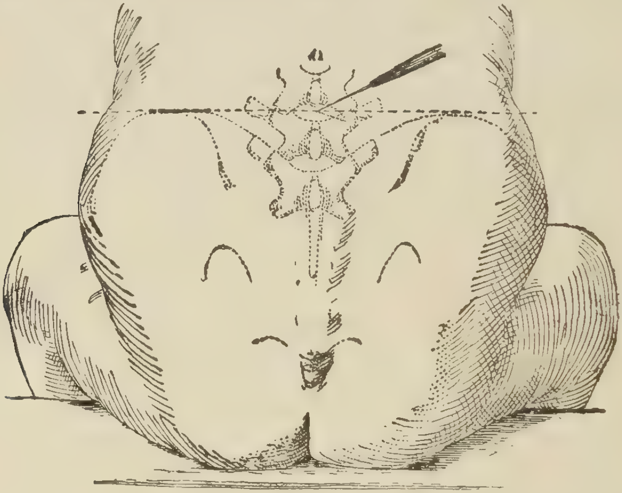

FIG. 606.—DIAGRAM OF PATIENT'S BACK IN THE SITTING POSTURE, AND SITE OF INJECTION FOR INDUCING SPINAL ANALGESIA.

The pointer merely indicates the *site* of injection, and *not* the direction in which the needle must be inserted.

The patient's back is purified, and he is placed either sitting with the head bent well forwards, or lies on his side doubled up. This position of flexion is most important in order to open up the invertebral spaces posteriorly. The site usually selected for the injection is the 3rd lumbar interspace (*i.e.*, between the 3rd and 4th lumbar vertebræ), and this corresponds to the summit of the iliac crests (Fig. 606). The spot is, if need be, frozen by chloride of ethyl, and then the needle is introduced in the middle line, and passes directly backwards and perhaps a little upwards. Some insert the needle about $\frac{1}{3}$ inch from the middle line, and then it must also be inclined a little inwards. If correctly placed, the resistance of the ligamentum subflavum is felt, and subsequently that of the dura mater. A successful puncture is followed by a flow of cerebro-spinal fluid, tinged at first, perhaps, with a little blood; a drachm or two may be allowed to escape, although the necessity or desirability of this is not proven, and then the stovaine solution is injected, and the needle is withdrawn. Should the needle impinge on bone, it is wisest to take it out andmake a fresh puncture, either through the same interspace or through the next above or below. After the injection the patient lies back with a support about 4 inches high, placed under the sacrum, so as to encourage the diffusion of the stovaine up the canal for a short distance. This upward dissemination must, however, be limited, as the analgesia is associated with motor paralysis, and obviously the respiratory muscles must not participate in this.

Analgesia usually develops in from five to twelve minutes, and often shows itself in the perineum before appearing in the feet. Gradually it extends over the whole lower extremity, and may reach to the umbilicus, or a little higher. It is accompanied by motor paralysis and loss of the reflexes, but the patient may be conscious of ordinary tactile sensations. A certain proportion of failures will be noted, and at present it is impossible to explain their occurrence. When the injection is successful, the patient lies quietly during the operation with complete muscular relaxation, and can engage in conversation, smoke a cigarette, or read a newspaper. The administration need not be followed by any restriction of diet, but some amount of headache may be experienced on the same or the following day, and in a few cases vomiting. After-results in the shape of nervous diseases involving the spinal cord have been reported in a few instances as coming on after a year or two; but it is a little difficult to be certain of the causal relationship of the injection.

At the present time the general opinion as to the value of this procedure is that, whilst in suitable cases it may be employed for operations below the umbilicus when a general anæsthetic is not desirable, yet as a routine method of inducing anæsthesia it has but slight advantages over the ordinary plan. It is not always certain; the injection is not always painless; the after-results are sometimes unpleasant; the patient is not protected from nervous shock and apprehension *during* the operation; and the question of late nervous sequelæ still remains to be decided. On the whole, its employment may be advised when a general anæsthetic is undesirable owing to the condition of the patient's heart, lungs, kidneys, etc.; when diabetes is present in an aggravated form; when the surgeon is short-handed; and when very complete muscular relaxation is required, as in dealing with fractures. The absence of struggling during and after the administration of a general anæsthetic makes it particularly desirable in the last of these conditions.

3. **General Anæsthesia by Inhalation.**—(1) **Nitrous Oxide Gas** (NO_2) is most commonly used in dental work, or for short operations, such as bending a stiff joint and breaking down adhesions, the avulsion of a toe-nail, or the opening of an abscess. It is practically safe and not unpleasant, either in its use or in its subsequent effects. It is also employed in conjunction with ether, the patient being first anæsthetized with gas, and the condition maintained by ether. Gas has also been recommended for the removal of adenoids; but the general opinion now obtaining is that, to perform this operation satisfactorily, a more lasting anæsthetic is required. The gas is stored in a condensed and liquefied form in special steel cylinders, closed by a screw which can be readily loosened, so as to allow the gas to escape through a tube into an indiarubber bag. This is attached to a closely-fitting face-piece, with a suitable arrangement of valves and stop-cocks, by means of which the gas is allowed to reach the patient. A valvular exit for the expired air is also present (Fig. 608). In its usual method of administration the bag is first filled with gas, and then air is completely excluded by carefully adjusting the padded face-piece to the irregularities of the face. Some anæsthetists, however, by means of a special apparatus devised by Sir Frederick Hewitt, allow the administration of a minute proportion of pure oxygen at the same time, in order to prevent the lividity of the face and the twitching of the limbs often present when anæsthesia is induced in the ordinary way. These symptoms of incipient asphyxia may also be avoided by allowing the last few inspirations of the gas to be mixed with air. This may be done by raising the face-piece, by opening the air-valve, or, as suggested by Dr. Flux, by using an open inhaler into which the gas is poured. Of course, in removing teeth the mouth is firmly gagged open prior to the commencement of the administration.

(2) **Chloroform** is perhaps the anæsthetic most generally employed, on account of the ease with which it can be administered, although there can be but

little doubt that its use is attended with somewhat more risk than that of ether. Much controversy has arisen as to whether the heart is ever directly affected by the drug, or whether the dangerous symptoms met with are not due to primary failure of the respiration. The experimental evidence on the subject is of a very conflicting nature; and it is impossible as yet to consider the question solved. The Scotch school of surgeons, headed by Syme and Lister, has always maintained that the breathing alone need be watched during the administration of chloroform, failure of the respiration being the first danger-signal; the second so-called Hyderabad Commission has sought to confirm this view. Many practical surgeons and anæsthetists oppose the statement, holding that, although the respirations may fail first in a large percentage, and probably a majority, of fatal cases, yet there are a certain number in which heart failure is also seen as a result of the direct toxic effect of the chloroform upon its muscular substance. Certainly in not a few instances of death during the administration of chloroform the heart stops first, but a great distinction must be drawn between the *deaths* which result *from chloroform*, and the *deaths* that occur *during* the administration of *chloroform*. An overdose of chloroform, without doubt, leads to failure of the respiration; but in the majority of such cases, if suitable precautions are adopted sufficiently early, a fatal result may be averted. Cases in which the heart stops first are probably due to syncope, and are not entirely dependent on the nature of the anæsthetic administered.

Attention has been drawn recently to a condition known as *delayed chloroform poisoning*, which is chiefly observed in children, and especially in cases where grave toxæmia is present. It commences about 12 hours after the administration with vomiting, the ejecta usually resembling beef tea, which persists in spite of all treatment, and the child becomes drowsy, apathetic, and finally dies about the fifth day in a condition of coma. Some slight degree of icterus may be noted. The breath smells of acetone, and the blood and urine contain both acetone and diacetic acid; these, however, can often be detected in children after chloroform, and in some other conditions.* *Post-mortem* the most marked phenomenon is an intense fatty degeneration of the liver, and to some extent of other organs; but Guthrie thinks that the hepatic condition has probably preceded the administration to a slight extent, and that the chloroform was merely the final element in determining the outbreak of trouble. In adults a similar condition arises a day or two after the operation, and perhaps most commonly in cases of grave toxæmia, *e.g.*, suppurative appendicitis. The symptoms are those of acute yellow atrophy of the liver, including persistent vomiting, well-marked jaundice, delirium, and finally coma. The liver is extensively involved, and undergoes evident degenerative changes. Nothing can be done as a rule, although the indications are to reduce the toxic absorption from the wound as far as possible, and to flood the system with alkalies. As a prophylactic, glucose in doses in 1 drachm, t.d.s., has been recommended. Death is the usual outcome, and occurs about the third day. A similar condition of hepatic disorganization may also occur after the administration of ether, and, indeed, may develop irrespective of operative interference of any kind.

Chloroform may be given in several different ways, but in all the chief points to be attended to are regularity of dose, and full admixture with air, so that not more than 4 per cent. of the vapour is inspired. The plan so often employed of pouring an unknown quantity of chloroform on a piece of lint, folded in two or three layers and held close to the patient's nose and mouth, is most unscientific and to be strongly condemned. The **Open Method** is that recommended by Lord Lister. A mask reaching from the root of the nose to the chin is made from the side of a towel, and fixed with a safety-pin. This is first held some inches above the patient's nose, and moistened from the outside with chloroform from a drop-bottle. As the respiratory passages become tolerant of the drug, the mask is gradually lowered to touch the face, and is kept continually moistened. At the end of two or three minutes the respiration increases in frequency, and a stage of excitement may be reached, during which the patient may sing, shout, or struggle violently. The anæsthetic is still cautiously pushed, care being taken that during the deep respirations which follow the struggling stage an overdose is not administered. Complete anæsthesia is indicated by relaxation of the muscles, loss of the corneal reflex, and contraction of the pupil, and it is usually attained in about five minutes. As long as the operation lasts, the anæsthetist must endeavour to maintain this condition, but the amount needed during the later stages is much less than at its commencement. Another and a better plan is to employ a Schimmelbusch's mask (Fig. 607), over which are stretched one or two layers of domette or five or six of gauze. The liquid is dropped on this surface in separated drops at short intervals, not in a continuous stream.

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* To test for acetone, the urine is first rendered alkaline by caustic potash. To this is added a few drops of a newly prepared concentrated solution of sodium nitro-prusside. If acetone is present the mixture becomes a reddish-violet colour, which turns blue on standing, or yellow on the addition of acetic acid. If a solution of ferric chloride is added to the alkaline urine, a claret colour is produced.

Junker's inhaler is often used for giving chloroform, especially in operations about the nose and face. It is economical, and on the whole satisfactory. In this apparatus air is pumped through a layer of chloroform to a face-piece placed over the patient's mouth, or to a tube passed into his nose. The air laden with chloroform vapour is inspired, and produces the usual constitutional effects; the amount administered is, to a certain extent, regulated by the rapidity with which the indiarubber bulb of the apparatus is squeezed; after a time, however, the lowered temperature induced by the evaporation leads to a diminution in the amount of chloroform vapour given off. Accidents have happened with this apparatus from filling the bottle too full, or from having the indiarubber tubes fixed to the wrong nozzles; in either instance liquid chloroform may be pumped out of the exit-tube.

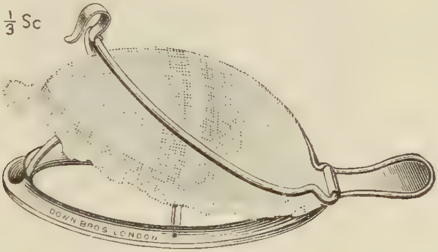

FIG. 607.—SCHIMMELBUSCH'S MASK FOR THE ADMINISTRATION OF CHLOROFORM. (DOWN BROTHERS.)

(3) **Ether** is generally considered to be a safer anæsthetic than chloroform, in that it is a cardiac stimulant. It is usually administered by Clover's apparatus or by an open method.

Clover's apparatus (Fig. 608, D and E) consists of a face-piece similar to that utilized for giving nitrous oxide, a metal receptacle for the ether, and a bag. In this apparatus the air used in respiration passes over the surface of the ether contained in the receptacle, the proportion of ether inspired being regulated, so that at first a considerable admixture of air is permitted, whilst later on ether vapour in the proportion of a third, a half, or even two-thirds, is inhaled. The chief advantage of this apparatus is the ease with which the amount of ether administered is regulated; but a distinct disadvantage exists in the fact that the patient breathes his own expired air again and again, and so, unless care is taken, he is likely to become cyanosed. This can, however, be prevented by removing the mask occasionally, and giving the patient a few breaths of unmixed air. Another objection lies in the amount of mucus which often collects about the pharynx, whilst the moisture in the expired air condenses in the bag, which becomes very objectionable unless carefully washed out after each administration.

In the administration of ether it is now usual to adopt what is known as the 'gas and ether method,' by which is meant that the patient is first anæsthetized with nitrous oxide, and the anæsthesia is continued and maintained by means of ether. If the Clover's inhaler is to be used, the arrangement shown in Fig. 608 is employed, a Clover's ether-chamber being interposed between the

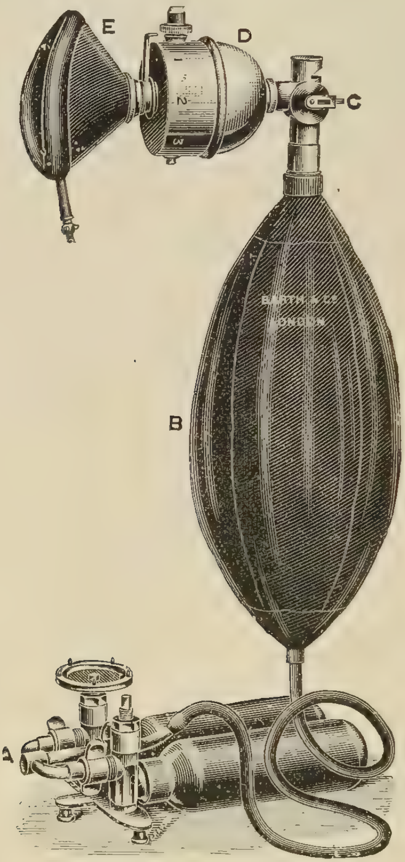

Fig. 608.—Apparatus for the Administration of Nitrous Oxide and Ether in Combination.

A, Steel cylinders containing compressed nitrous oxide; B, indiarubber bag; C, three-way stop-cock with valves; D, Clover's ether chamber; E, face-piece. If nitrous oxide alone is administered, D is omitted. When ether alone is used, A and C are omitted, and a smaller bag substituted for B.

face-piece and the three-way tube of a nitrous oxide apparatus. The patient is first allowed some six or eight full inspirations of nitrous oxide gas, and then the ether-chamber is turned to permit of gradually increasing doses of ether vapour. As soon as symptoms of nitrous oxide narcosis present (twitching of muscles, irregular stertor, etc.), the gas-bag is detached and the ordinary ether-bag substituted.

The advantages claimed for this ‘ combined method ’ are that anæsthesia is induced much more rapidly (two minutes), and, what is far more important, the process is much less unpleasant for the patient than when ether alone is employed. The patient is apt to become rather livid and rigid, but these conditions pass off in the course of a minute or two.

Of late years it has become the fashion to administer ether by what is termed the **Open Method**—*i.e.*, in much the same way as in the administration of chloroform. A Schimmelbusch's mask is employed (Fig. 607), with three or four layers of domette or six or eight layers of gauze; the irregularities of the face are filled in with strips of cotton-wool, and the ether is dropped on in a series of very rapid large drops, the supply being maintained at much the same rate throughout the whole operation. It is usual in this country to commence with chloroform or the A.C.E. mixture, and better results will be obtained if the administration is preceded by an injection of morphine $\frac{1}{6}$ gr. and atropine $\frac{1}{120}$ gr., given about an hour beforehand. The chief objections to this plan are the large quantities of ether required, and the consequent discomfort caused to the operator and his assistants. This, however, can be minimized considerably by giving it in the semi-open method as for A.C.E.

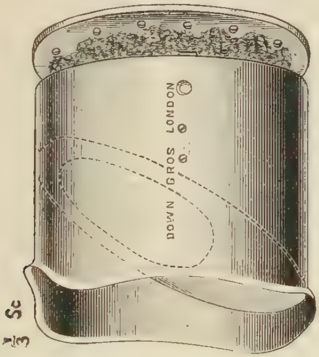

FIG. 609.—**SILK'S** MODIFICATION OF RENDLE'S MASK (DOWN BROTHERS.)

(4) To obviate the depressing effects of chloroform, a combination known as the **A.C.E. Mixture** is often used, consisting of alcohol, chloroform, and ether, blended in the proportion of one, two, and three parts respectively. It may be given either from a Rendle's mask, or by the open method as for chloroform, but the latter plan is only applicable to children and weakly individuals, who require but little anæsthetic. *Rendle's mask* consists of an oval box open at one end and shaped to fit the nose and mouth, and the fundus perforated with holes to permit of the free entrance of air; it may be made of leather, or preferably of celluloid or metal (Fig. 609). Two or three sponges are placed within it, and soaked with the anæsthetic, the patient breathing in and out of the cone. The inspired air is thus laden with the vapour, and the amount admitted is regulated in measure by covering a certain proportion of the inlet holes with the hand. The objection to this reagent is that it evaporates somewhat unequally, the ether coming off first, and leaving an excess of chloroform, which may be dangerous; this can, however, be obviated by

re-moistening the sponges alternately with the mixture and with pure ether.

(5) During recent years **ethyl chloride** has been introduced as a general anæsthetic with excellent results. It may be used (*a*) for short operations on the mouth or nose—*e.g.*, tooth-extraction or removal of adenoids, where a single dose is sufficient for the purpose; (*b*) for minor operations elsewhere—*e.g.*, opening abscesses, reducing fractures and dislocations; and (*c*) for inducing anæsthesia, which can be maintained by ether, in prolonged operations. Its utility is limited by its extremely volatile nature and by the method which must be employed in its administration. For this purpose the bag of a nitrous oxide or of an ether apparatus is utilized (it has no action upon rubber); 2 or 3 c.c. are poured into it, and the face-piece is firmly placed over the patient's mouth and nose. Anæsthesia is induced very rapidly, and recovery is equally rapid, but is rather apt to be followed by sickness and depression. Another use for this drug is as a preliminary to the use of ether or the A.C.E. mixture. In the latter case from 8 to 10 c.c. are poured upon the sponge of a Rendle's mask, and as soon as the patient becomes unconscious a full dose of the mixture is added. An undue proportion of fatalities have been recorded from the use of ethyl chloride, so that it is unwise to place it in the hands of the unskilled or inexperienced.

4. There are three **non-inhalation methods of administering ether** which have proved useful in certain special cases:

(1) **Intravenous.**—A vein in the bend of the elbow or over the internal malleolus is opened under a local injection, and a cannula is tied in; a slightly warm solution of 1 part of ether to 20 of sterile normal salt solution is allowed to flow into the vein through this cannula in a steady but small stream. Anæsthesia is induced very rapidly, and is of a very satisfactory nature, and capable of accurate adjustment. To ensure the steadiness of the supply, an apparatus with a regulating dripper, similar to that required for continuous proctoclysis (Fig. 457), is required.

The chief objections and difficulties connected with the plan are the trouble and pain attendant upon the preliminary proceeding of finding the vein, and the large amount of fluid (3 pints or more in a long case) which it is sometimes necessary to inject; this may give rise to cardiac dilatation, increased venous oozing, and other troubles. To some extent the amount of fluid may be diminished by the addition of from 5 to 10 grains of hedonal to each pint of the fluid.*

This method is particularly indicated for patients who are already much collapsed as the result of disease, or when one has reason to anticipate a severe degree of collapse as the result of the operation. It has also been used with advantage when it has seemed desirable that the anæsthetist and his paraphernalia should be removed as far as possible from the operation area.

(2) **Intra-tracheal Insufflation of Ether.**—In this method one endeavours to set up a condition of artificial respiration similar to that adopted in the physiological laboratory, anæsthesia being maintained by means of warm moist ether vapour introduced under pressure. The patient is prepared in the ordinary way, and a preliminary full dose of morphia and atropine administered. He is then deeply anæsthetized by means of chloroform, and the head being placed in a proper position, the vocal cords are brought into the field of view of a bronchoscope (Fig. 432). A soft catheter is then passed through the glottis and as far down as the bifurcation of the bronchi, care being taken that the catheter does not entirely fill up the opening of the glottis, but allows a sufficient interval to permit of the escape of the expired air. Air mixed with the necessary amount of ether vapour is driven through the catheter by means of a specalized form of apparatus worked by a foot bellows or an electric force-pump. The air is supplied at a pressure of from 15 to 20 millimetres of mercury, and to avoid over-distension of the pulmonary tissues the pressure is allowed to fall to nil two or three times per minute. The return current of air along the sides of the catheter sweeps before it any

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* In cases of tetanus this addition is of considerable therapeutic value.

blood or mucus that may have trickled into the trachea or accumulated in the mouth.*

The method is clearly complicated and difficult, and except in a few isolated and exceptional cases it is doubtful whether the results are so very superior to those obtained by the administration of the anæsthetic in a simpler fashion. It is chiefly useful in intra-thoracic cases, when it is desired to distend the collapsed air-vesicles, and in extensive tongue and mouth cases, to sweep out the accumulations of blood and mucus. The plan has also been advocated for abdominal operations, on the ground that the diaphragmatic action is reduced to a minimum, and the manipulations of the surgeon facilitated; but it is very doubtful whether this reduction is really more than could be obtained by the proper administration of an anæsthetic in the ordinary way, and it is certainly largely due to the prior administration of alkaloids by which the intra-tracheal method is preceded.

(3) **The Rectal Administration of Ether** has advantages which are sufficiently obvious in such operations as those on the mouth or pharynx. It has been found, however, that when liquid ether alone is used more or less severe colitis is set up, while if the vapour be employed, the period of induction is unduly prolonged and the degree of anæsthesia is out of control. More recently Dr. Gwathmey, of New York, has suggested the injection of a mixture of oil and ether. The rectum having been well washed out with warm water, about 8 to 10 ounces of a mixture of olive oil and ether, in the proportions of 3 of oil to 1 of ether, is injected very slowly into the bowel. About half an hour should be taken in the process, by the end of which time the stage of excitement should become apparent, and a little chloroform or ether given by inhalation will assist the development of the full degree of anæsthesia. It is usual to use a double tube for the injection, so that at any moment the rectal contents can be withdrawn, as should always be done at the end of the operation. The resulting unconsciousness is not very deep, but it forms an excellent basis for the maintenance of inhalation anæsthesia, especially in the neurotic, in people who are very liable to sickness, or whenever it is desirable to limit the amount of vapour given by inhalation.

General Remarks as to the Administration of Anæsthetics.

The medical practitioner must never lose sight of the fact that a certain element of risk is necessarily attached to the artificial induction of a condition in which the activity of the nervous system is entirely suspended, except for the maintenance of those phenomena which are actually essential for life. Hence, an anæsthetic should never be given, unless absolutely necessary, without careful preparation of the patient, or such examination as shall satisfy the doctor as to his capability of safely taking it.

The **Preparation of the Patient** is a most important proceeding. When practicable, the general habits of the individual should be carefully regulated for a few days prior to the operation, and on the preceding day a suitable purgative is administered, castor oil being, perhaps, the most efficacious. Any food given on the morning of the operation should be light and easily assimilable, whilst nothing should be taken for at least three hours previously, so as to make sure that the stomach is empty. In casualty cases, it may be advisable to relieve gastric distension with an emetic, or by washing out the organ before commencing the administration. The anæsthetist must ascertain that no loose artificial teeth are present in the mouth, and that no tight clothes or bands encircle the neck or thorax. In very nervous patients, or where much shock is anticipated, a preliminary hypodermic injection of strychnine or a nutrient enema may be administered.

The preliminary hypodermic administration of scopolamine (gr. $\frac{1}{64}$) and morphine (gr. $\frac{1}{6}$) has been recommended by some authorities as a means of inducing ordinary sleep, and thereby diminishing the amount of anæsthetic required.

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* For further details of this and other non-inhalation methods, see 'Modern Anæsthetics,' Silk, 1914.

A dose is given three or four hours, and another one hour, before the time of operation. There is a good deal of difference of opinion as to the value of this procedure; sometimes it acts perfectly, and the patient escapes the discomforts caused by the larger doses of anæthetic; at other times it causes great muscular rigidity and increased bleeding, so that some surgeons condemn it most vigorously. On the whole, it would rather appear as though the good effects of this preliminary medication were mainly due to the morphine, and that the addition of the scopolamine is unnecessary. A good combination is morphine (gr. $\frac{1}{6}$) and atropine (gr. $\frac{1}{120}$), the very distinct advantages of the latter drug being that it diminishes the secretion of saliva and mucus, and probably counteracts the tendency to vagus inhibition of the heart's action which Embly* has shown to be one of the chief dangers of chloroform inhalation.

The anæsthetic should never be pushed in the early stages, but is given slowly and gradually, especially in nervous individuals. When there is any struggling, the movements of the limbs should be restrained with as little force as possible, and care must be taken during the deep respirations which follow such struggling not to administer an overdose. The condition which the administrator should aim at maintaining is one characterized by total muscular relaxation, insensitiveness of the cornea, and a contracted state of the pupil, whilst the pulse and breathing continue regular. If the pupil commences to dilate, and the corneal reflex is present, the patient is apt to move when the knife is used, indicating that more anæsthetic is required. Dilatation of the pupil with an insensitive cornea is always an indication for suspending the administration for a time. If the anæsthesia is not sufficiently deep, vomiting is likely to occur, being ushered in by weakness and rapidity of the pulse, and pallor of the face; this may often be averted by pushing the anæsthetic. The anæsthetist's chief attention must be directed to observing the state of the respiration and pupil; but he should also note the colour of the lips, cheeks, and ears, as thereby valuable information is gained as to the condition of the circulation. The pulse should be felt occasionally, but it is less important to attend to this than to the other points noted above. After the deep anæsthesia required in division of the skin, most operative proceedings on the subcutaneous tissues are comparatively painless, and hence the anæsthetic need not be pushed quite so far. Whilst the wound is being closed, the patient must be again somewhat more completely under control. In operations upon the mouth associated with hæmorrhage, the head must be occasionally turned to one side to allow the blood to gravitate out of the mouth, and the pharynx well sponged, so as to prevent the admission of clot and other matters into the air-passages. It is also a valuable routine plan to insist upon the head always being turned on one side, especially when ether is being given, since mucus tends to collect about the pharynx.

The **After-Treatment** of the patient is always a matter of considerable importance. He is carried from the table and placed on his back, or preferably, when possible, on his right side, in bed with the head low. When there is any tendency to shock, the patient should be well covered with hot blankets, and the foot of the bed raised by some 10 or 12 inches. As the skin of an anæsthetized patient is particularly insensitive, it is perhaps better to prohibit the use of hot-water bottles for at least twenty-four hours after the operation. For the further treatment of shock, see p. 267. Absolute quiet must be enjoined for some hours, and the room darkened, so that, if possible, the patient may fall asleep. No food is administered for at least three or four hours, and then only very cautiously, a little weak tea, soda-water, or beef-tea being given. The patient is likely to vomit on returning from unconsciousness, perhaps bringing up a little bile-stained mucus, but if the anæsthetic has been judiciously given, this soon ceases. Occasionally, however, the vomiting persists for some time, becoming very troublesome. It may generally be checked by a hypodermic injection of morphia, and by washing out the mouth with warm water; but in more severe cases, lasting for some days, the patient's nutrition may have to be maintained by enemata, and the stomach kept absolutely at rest. Benefit may sometimes be derived by giving a little bismuth and hydrocyanic acid in an effervescing mixture, or perhaps champagne; but, as a rule, all administration of food by the mouth should be stopped until the vomiting has ceased.

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* *Brit. Med. Journ.*, 1914, vol. i., p. 1902.

Three chief **Dangers** are encountered during the administration of anæsthetics:

1. **Obstructed Respiration** usually results from falling backwards of the root of the tongue, which blocks the entrance of air into the larynx. The respirations gradually become more and more stertorous, the face and ears become dusky, and, if the condition is not relieved, the chest continues to heave without any air entering or leaving it, and finally respiration ceases when the patient is completely asphyxiated. The early stages of this condition are of common occurrence, whatever the anæsthetic, and the administrator must always be on the look-out and endeavour to prevent it by turning the head or the patient himself so that the tongue falls to one side. If it occurs in spite of this position being adopted, the administration is at once suspended, whilst the tongue must at all hazards be drawn forwards. This may be accomplished in the early stages by pulling on the beard or chin, or by pressing the mandible forwards by the fingers placed behind the angle of the jaw In the later stages the mouth should be forcibly opened by a gag, and the tongue grasped by forceps and pulled well forwards, or a finger may be passed back into the pharynx to draw the root and epiglottis forwards, and at the same time ascertain that the entrance to the glottis is free from obstruction. Artificial respiration should be undertaken if the breathing has actually stopped. Death ought never to result from this cause, and if it occurs, it can only be attributed to the carelessness of the anæsthetist.

Obstruction to the respiration may occasionally arise from the entrance of vomited material into the air-passages or lungs, the patient becoming cyanosed during an attack of vomiting, and passing rapidly into a state of asphyxia. In such a case the finger must be swept round the pharynx, if the mouth can be opened, to see that the glottis is clear, whilst tracheotomy or laryngotomy may be necessary should the teeth be firmly clenched, or if the obstruction is below the entrance to the glottis. Fortunately, this accident is of rare occurrence.

2. **Complete Cessation of Respiration** is the usual primary phenomenon from an overdose of chloroform; it is also stated to happen occasionally during ether narcosis. The pulse continues to beat distinctly for a few seconds, although respiratory movements have ceased. Treatment consists in at once stopping the administration, whilst the tongue is drawn forwards, and the fauces cleared by the finger. The head should be lowered over the end of the table, and young children may even be completely inverted, so as to induce a flow of blood to the head. Artificial respiration is commenced without delay, whilst the thoracic parietes may be flicked with a cold wet towel, or alternately douched with hot and cold water. Strychnine or ether should also be injected hypodermically, and if the condition persists and the heart's action ceases, a Faradic current may be passed from the second or third intercostal space in front to an electrode placed over the spine. Attempts at resuscitation should be continued for half to three-quarters of an hour. At the same time, these measures must be undertaken with discretion, as otherwise it is quite possible to extinguish the feeble spark of life by the very means which, used wisely, would have restored it.

3. Death occasionally results from primary **Cardiac Failure,** which may arise *a*) from fright during the administration of the anæsthetic; (*b*) from shock with cardiac inhibition, by commencing the operation before complete anæsthesia has been obtained; and (*c*) from an overdose of chloroform or ether acting directly on the nerve centres or on the muscular substance of the heart. On post-mortem examination in such cases, the heart muscle is found to be thin and flabby, and perhaps infiltrated with fat; the ventricular walls are especially affected. Unfortunately, this condition cannot be recognised with certainty by the stethoscope. Patients with simple valvular lesions, where the defect has been more or less compensated, do not generally run any extra risk. The treatment to be adopted in cases of cardiac failure during anæsthesia is the same as for stoppage of the respiration.

In this connection it is important to note the association of sudden death from heart failure with the condition known as **Status Lymphaticus.** It usually occurs in children, and is characterized by overgrowth of the lymphoid tissues of the body, especially in the pharynx, and of the tonsils, abdominal and mediastinal glands. The thymus also remains enlarged, and the spleen and bone marrow may be in a condition of hyperplasia. The administration of an anæsthetic is by no means the only cause of sudden death in this condition, as it has been known to follow the hypodermic injection of antidiphtheritic serum, sudden plunging into cold water, and such minor ailments as bronchitis. It is usually only discovered after death, but if it is suspected, the greatest care must be exercised in administering an anæsthetic, since the lethal dose is obviously very small in such patients. Ether should be given, and for choice by the open method.

The **Choice of an Anæsthetic** in any particular case depends mainly on the condition of the circulatory and respiratory apparatus of the patient. Ether is perhaps, on the whole, the safest agent to employ, especially in adults, although it is less pleasant to take; it may cause a good deal of bronchial irritation and congestion, and is more likely to give rise to troublesome after-vomiting, although such does not usually last long. It is sometimes followed by unpleasant delirium. Chloroform is easier to administer, more pleasant to take, and less likely to lead to objectionable after-effects. It is the best anæsthetic for young children and old people, though its action upon the heart contra-indicates its use in patients whose circulation is weak, or where there is any suspicion of the existence of the status lymphaticus. The A.C.E. mixture may also be safely employed, if the precautions already indicated on an earlier page are attended to.

Ether is certainly contra-indicated in patients suffering from any bronchitic or pulmonary trouble, and its administration for operations about the face or mouth is, of course, impracticable. Chloroform should not be given in cases of cardiac weakness or advanced renal disease; for abdominal work it is usually preferred to any other agent, as also in operations on the brain, but it is important to note that in septic conditions in the abdomen—*e.g.*, suppurative appendicitis in children—the results of chloroform administration seem to be much less satisfactory than when ether is given. The mortality over an extended series of cases is much greater with chloroform than with ether.

Anoci-Association is the term used by Professor Crile, of New York, to describe a systematic method of operating devised by him in order to give practical effect to his views upon the causation of surgical shock.

According to Professor Crile,* 'the essential lesions of shock are in the brain-cells,' and are caused partly by emotional or psychic shocks (*e.g.*, fear), and partly and mainly by afferent impulses from the site of the operation.

Psychic shocks are to be prevented by careful preparation of the patient, who should, as far as possible, be kept in ignorance of the exact day and time of the operation. In the emotional (*e.g.*, thyroid cases) this principle is carried to the extent of occasionally anæsthetizing the patient with nitrous oxide, under the guise of treatment.

Afferent impulses are prevented by temporarily destroying the conductivity of the nerves in the immediate vicinity of the operation area, by the infiltration of the tissues with weak solutions of local anæsthetics applied systematically to each layer. In an abdominal operation, for instance, the procedure would be as follows:

1. A dose of morphine (gr. $\frac{1}{6}$) and scopolamine (gr. $\frac{1}{150}$) is given an hour before operation.

2. Just sufficient general anæsthetic is given to render the patient unconscious—nitrous oxide with a little ether by preference.

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* *Lancet*, July 5, 1913, p. 7, and Seventeenth International Congress of Medicine.

3. The skin and subcutaneous tissues over the point of the incision are infiltrated with novocaine (1 in 400). Each succeeding layer of fascia, muscle, aponeurosis, etc., is infiltrated as it is exposed.

4. As needs be, the meso-appendix, the base of the gall-bladder, the uterus, the broad and round ligaments, the mesentery, etc., are treated in the same way.

5. The site of the closing stitches is infiltrated with quinine-urea (½ per cent.), which, by the effusion it produces, assists in sealing the wound.

The amount of the anæsthetizing fluid used is immaterial, as in the strength employed it is practically innocuous.

It is claimed that by these systematic measures the whole of the injurious impulses to the brain-cells are blocked, and the recovery of the patient much facilitated.

Professor Crile's followers have for the most part been much less systematic, and the term ' anoci-association ' is now applied to the free use of weak solutions of local anæsthetics applied haphazard; but even in this limited sense a certain amount of success has attended the procedure. The educational element of the plan hardly seems practicable in this country

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